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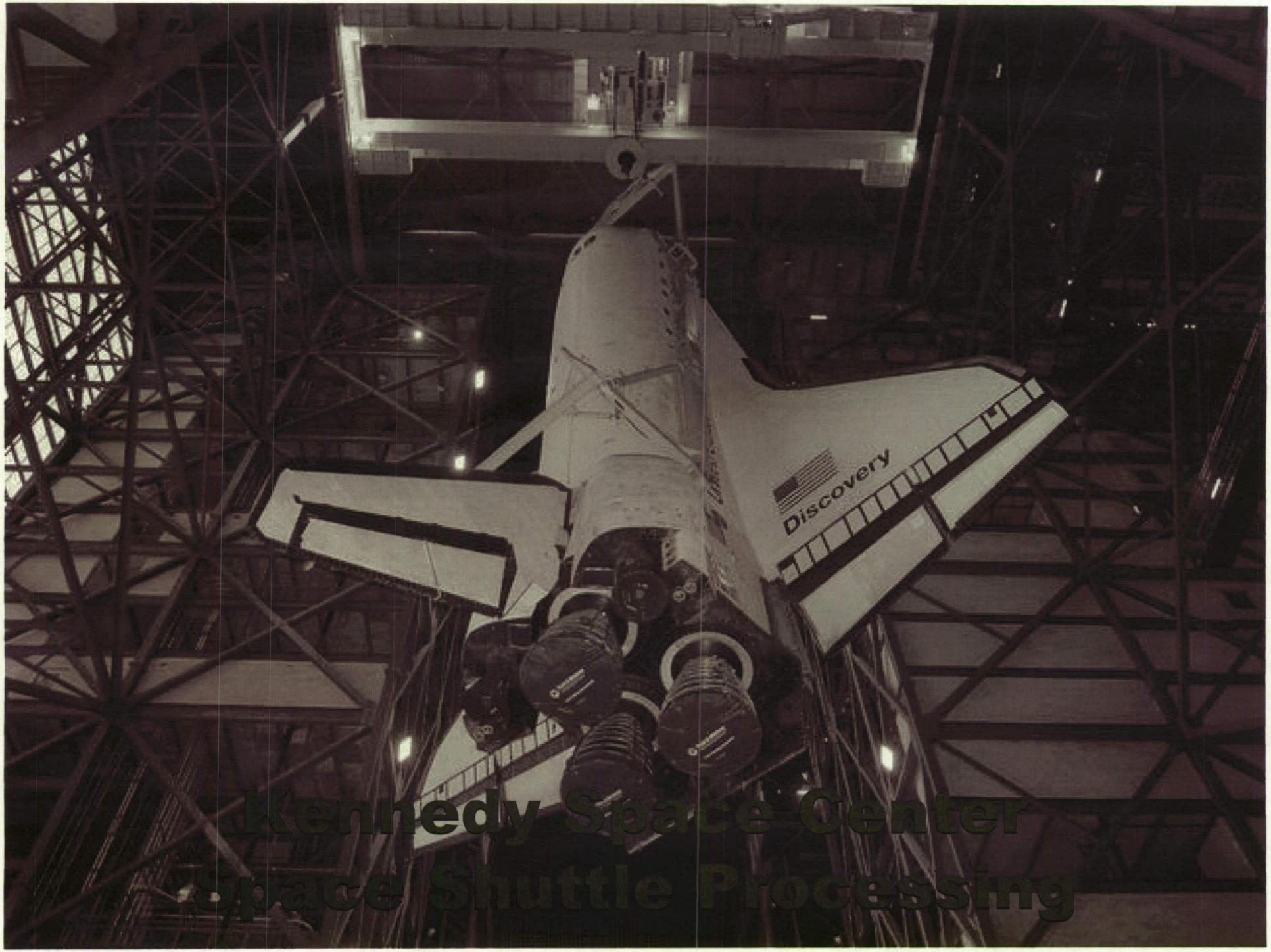
Produced by the NASA Center for Aerospace Information (CASI)

Presentation for
North American Crane Bureau
Professional Development Conference
November 2008

Joe Torsani
and
Brad Lytle

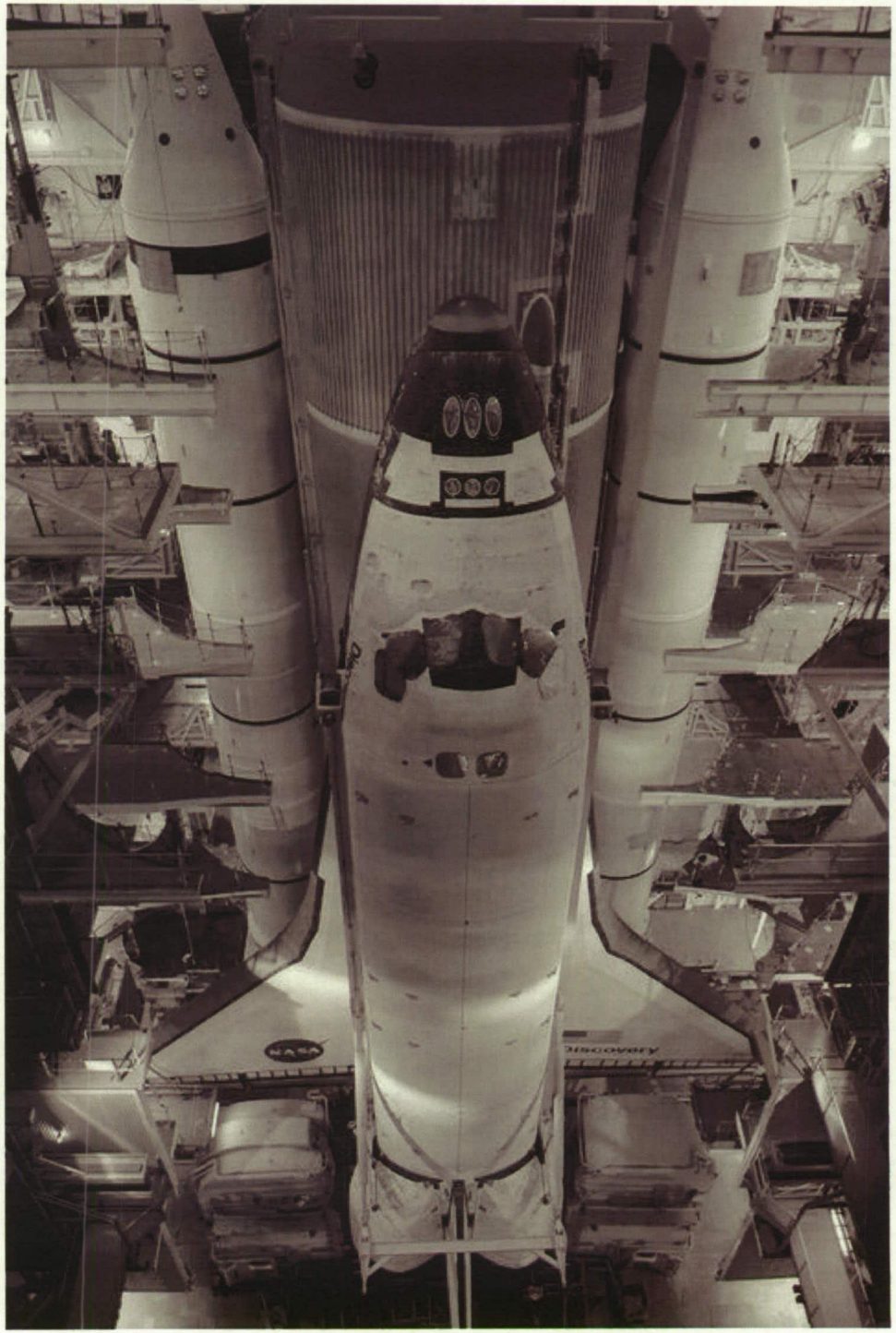


Kennedy Space Center
Space Shuttle Processing

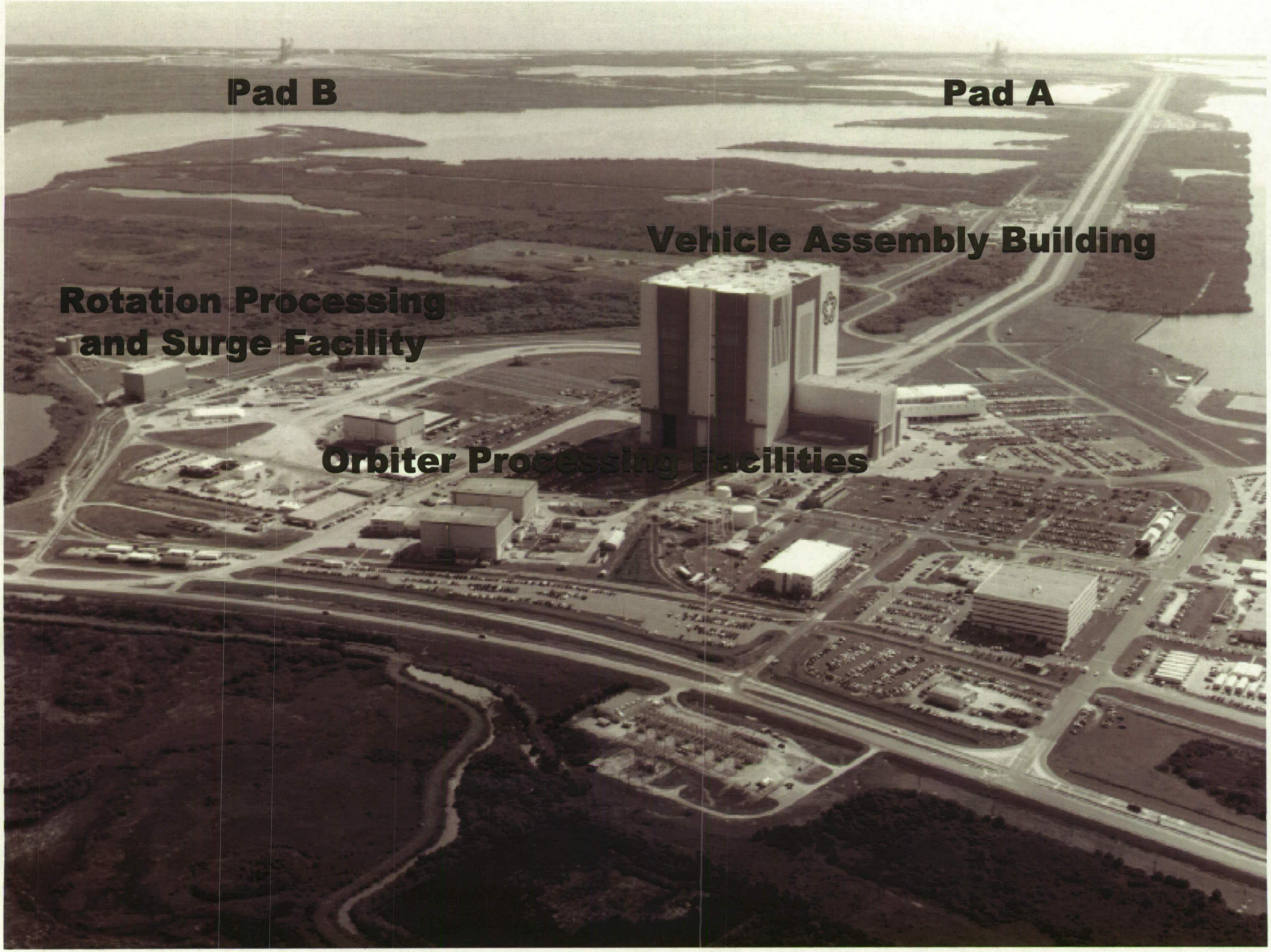
Space Shuttle
Processing Flow
Launch Complex-39 Facilities
Exterior 325-Ton Bridge Cranes

Space Shuttle

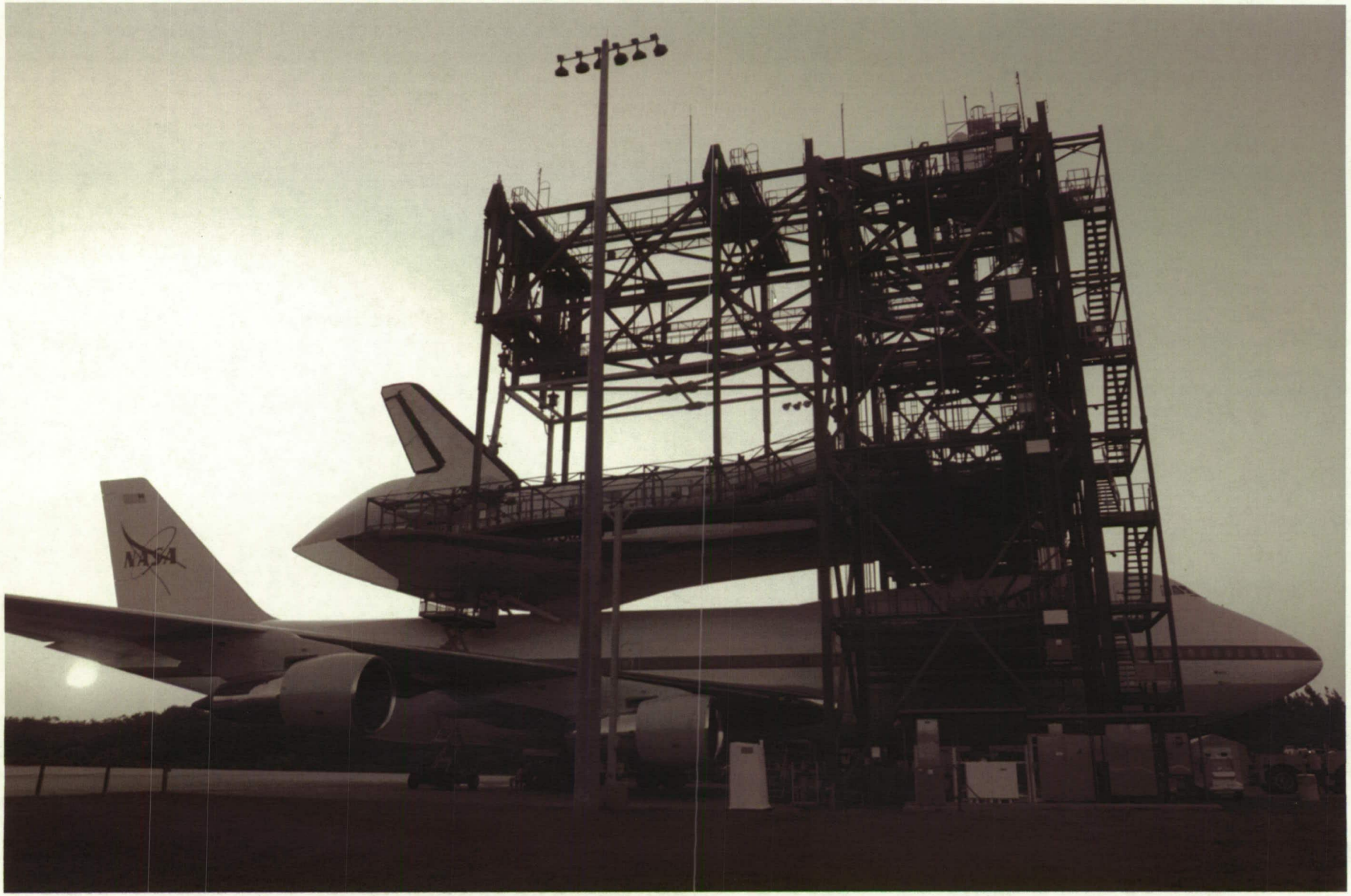
- Orbiter
- External Tank
- Solid Rocket Boosters



Launch Complex-39

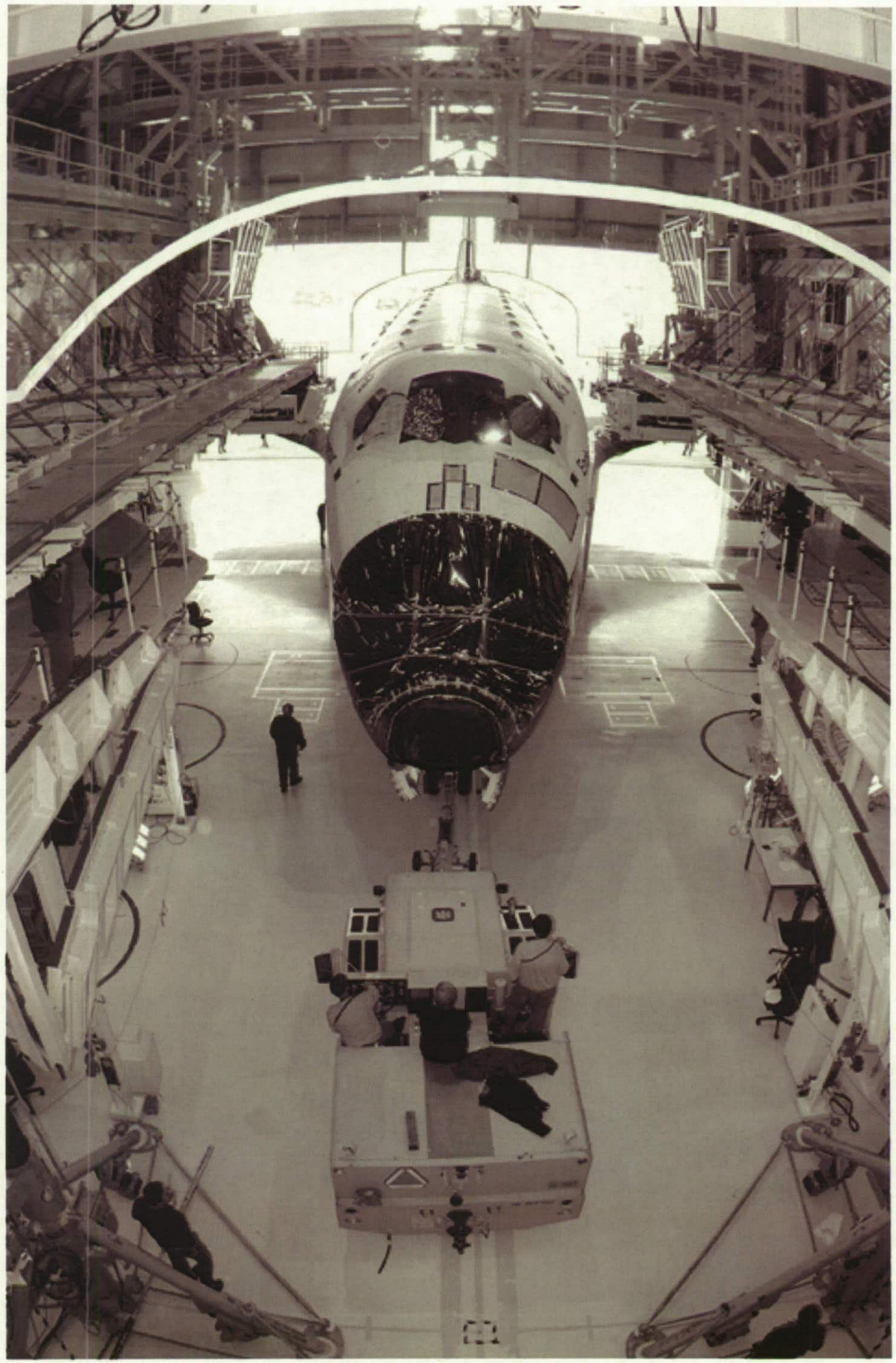

Pad B
Pad A
Vehicle Assembly Building
Rotation Processing
and Surge Facility
Orbiter Processing Facilities

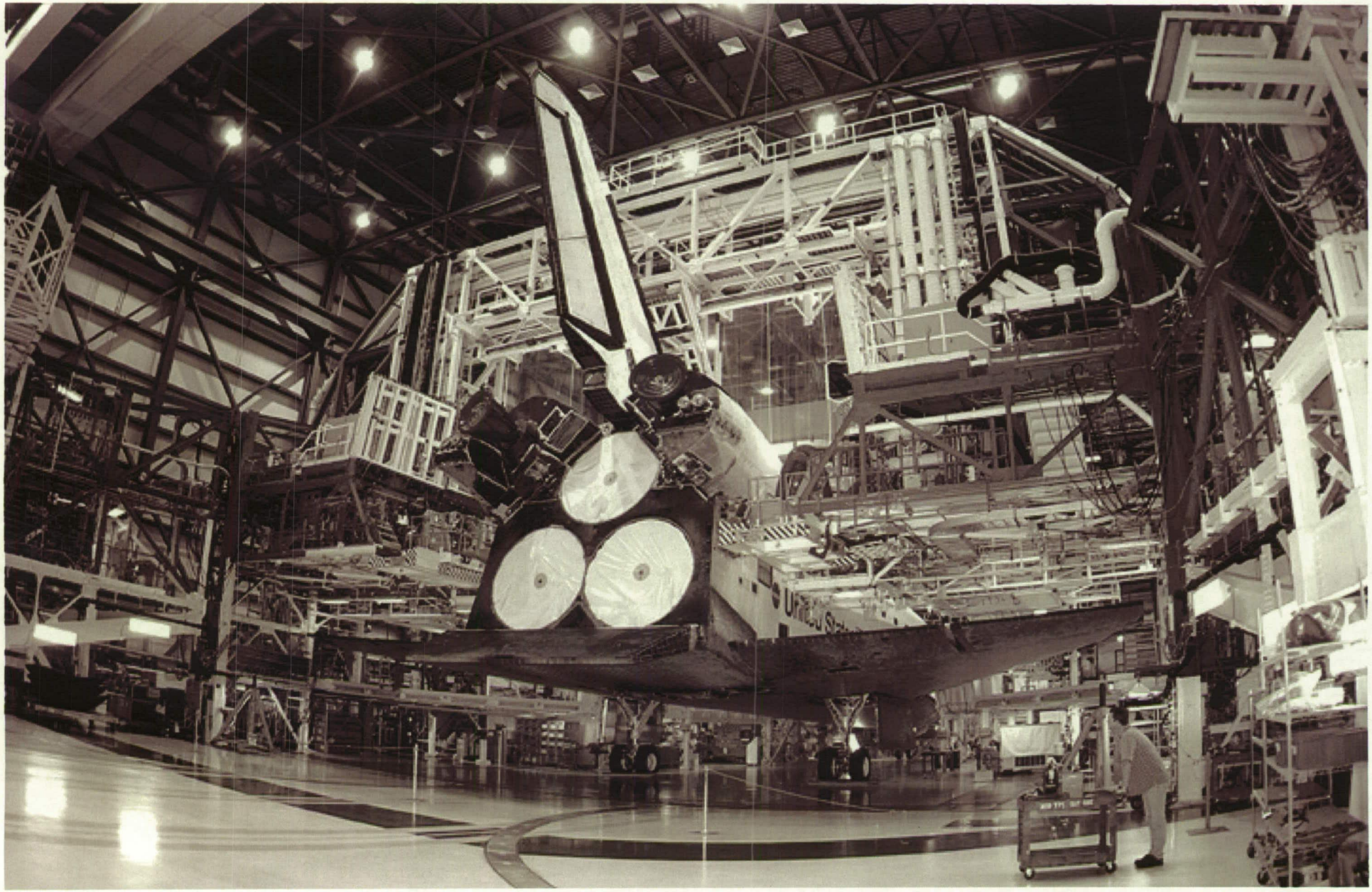
Mate De-mate Device



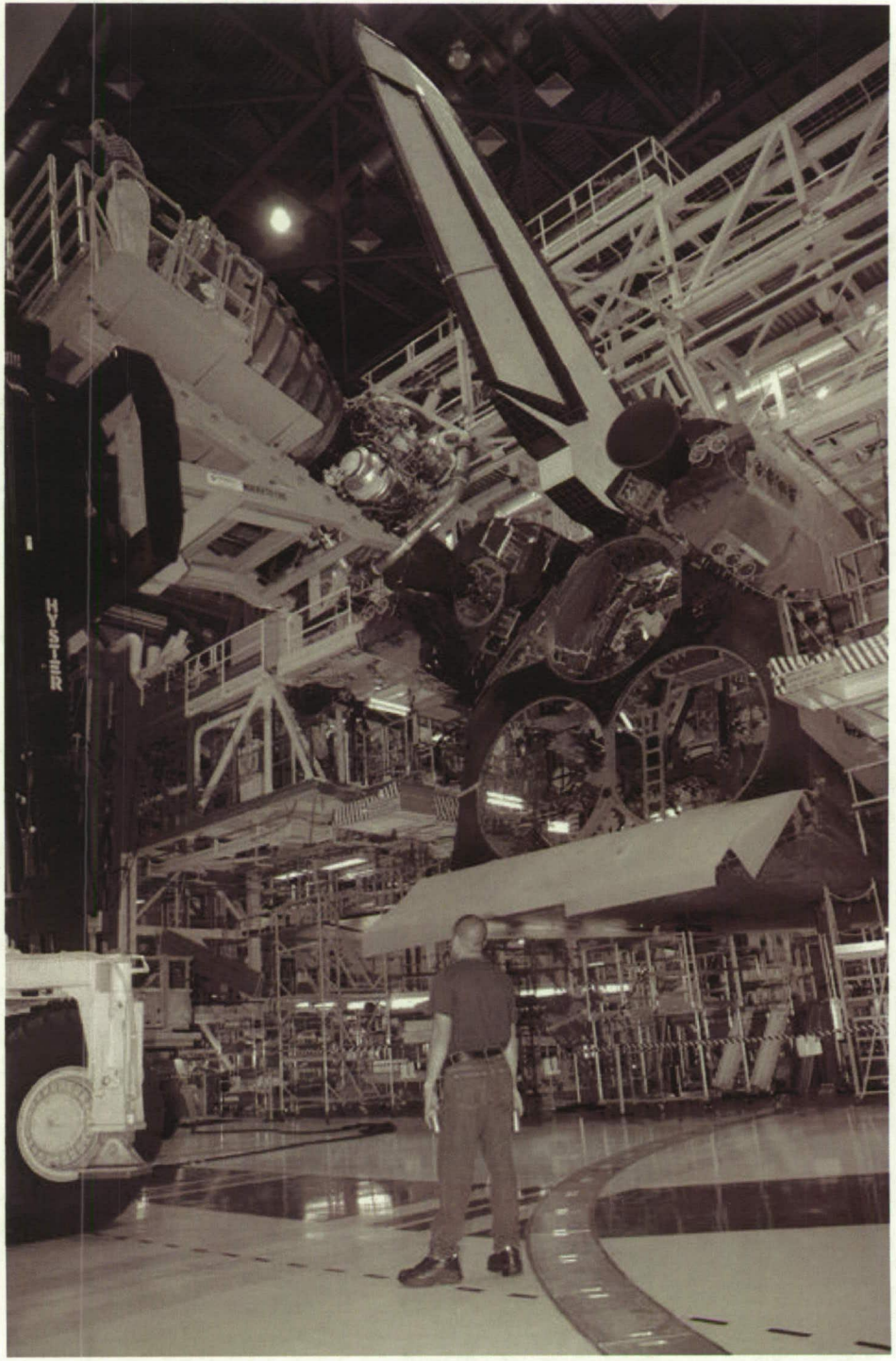
USA

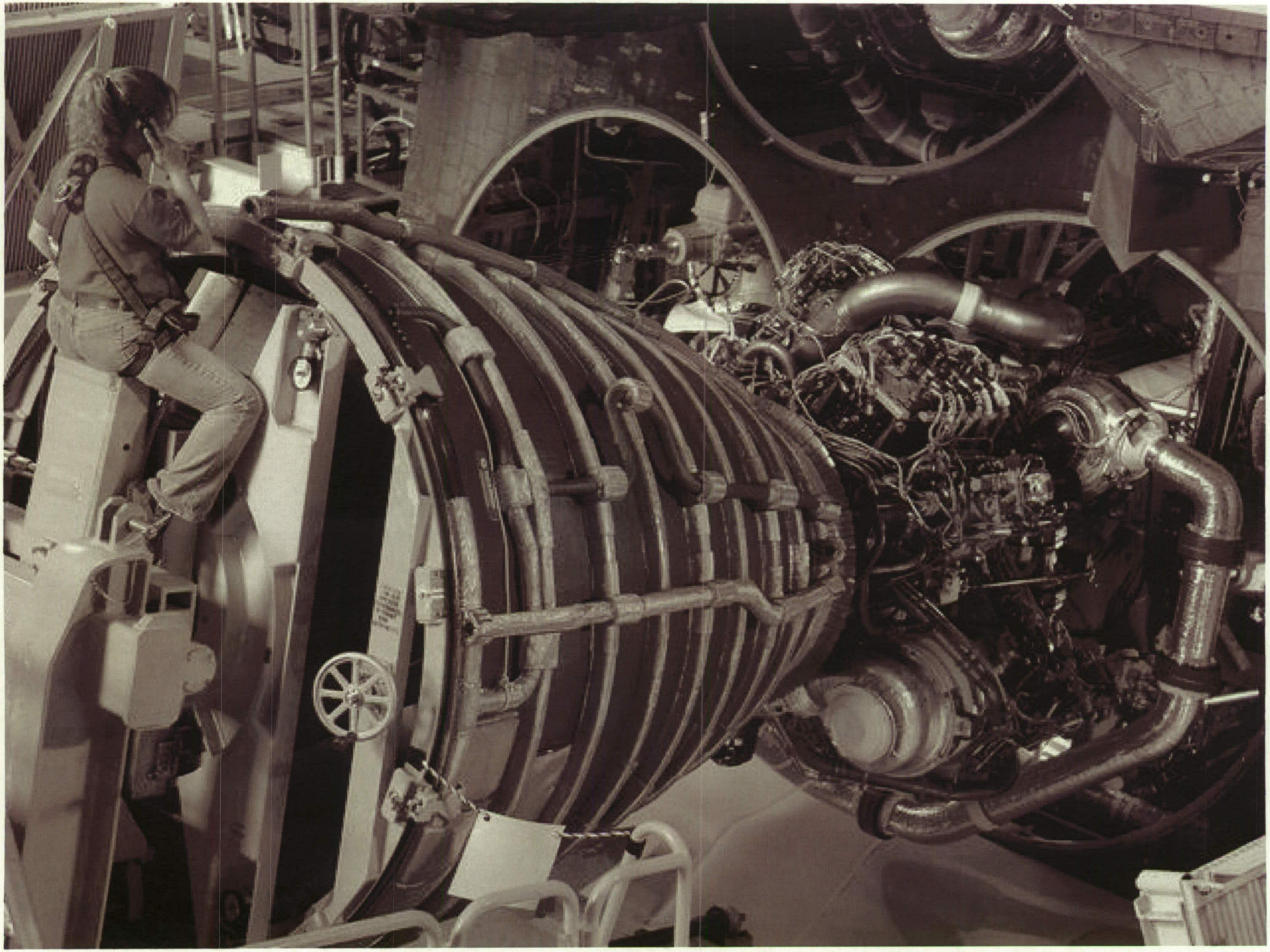
Orbiter Processing Facilities



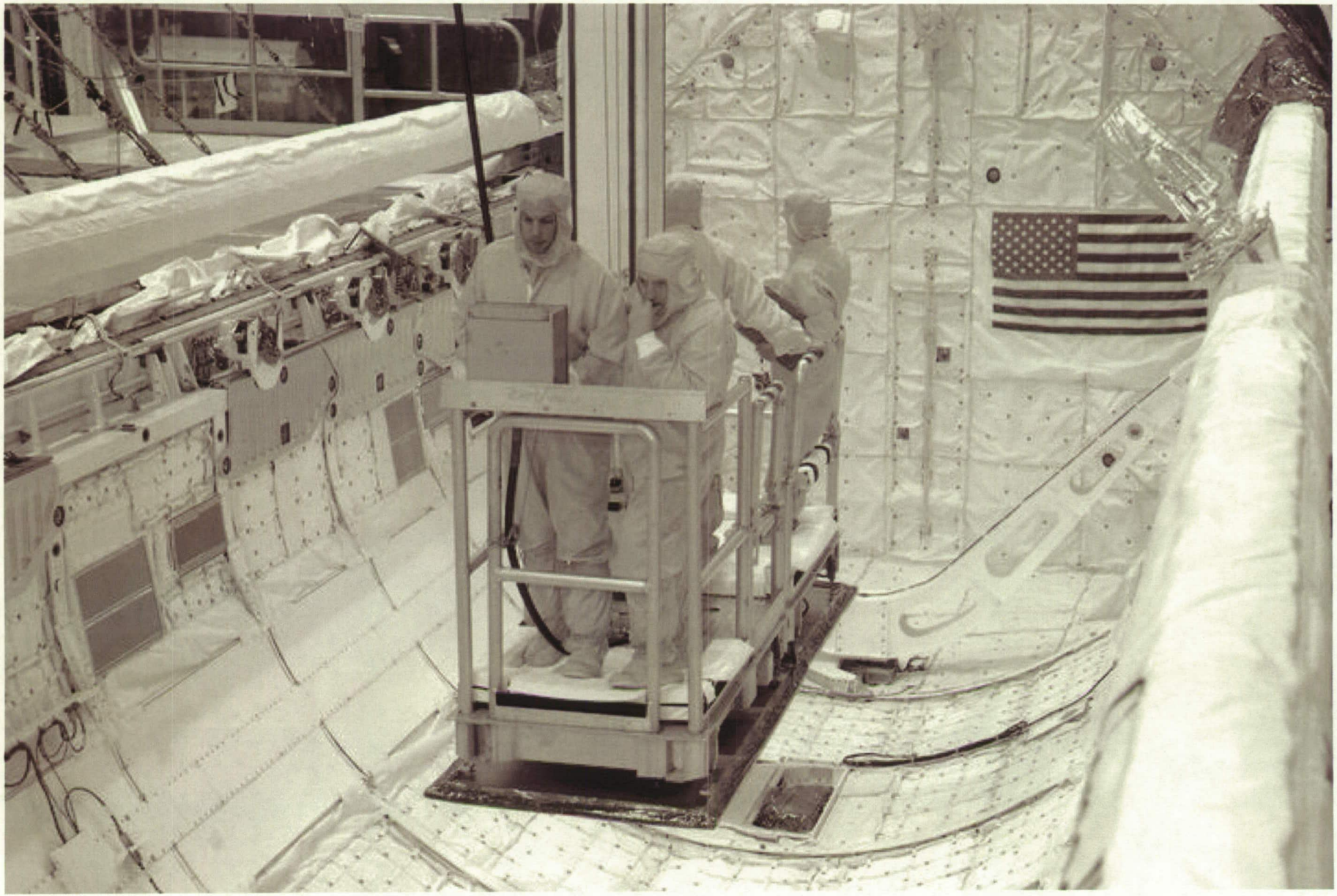


Space Shuttle Main Engine Installation

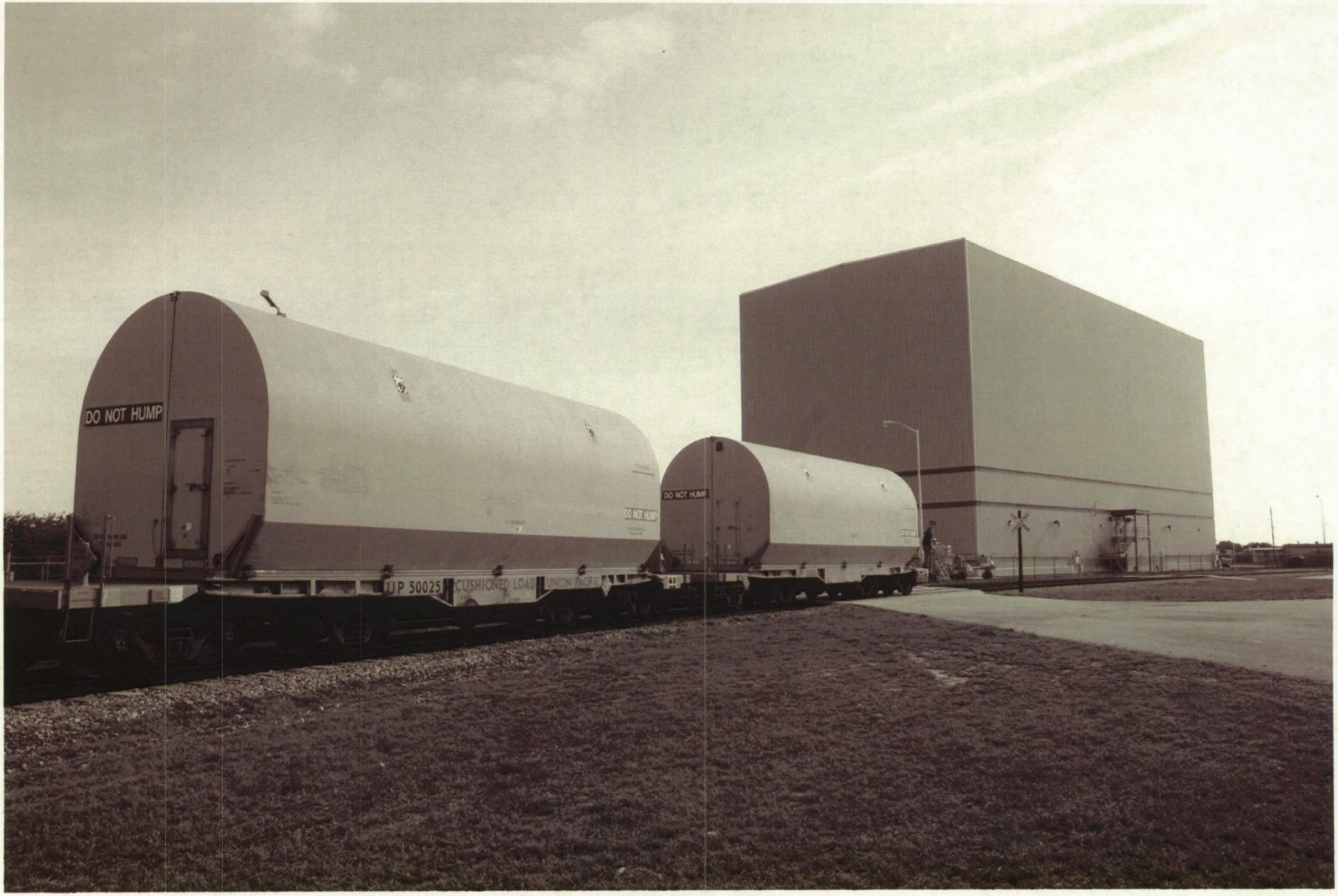


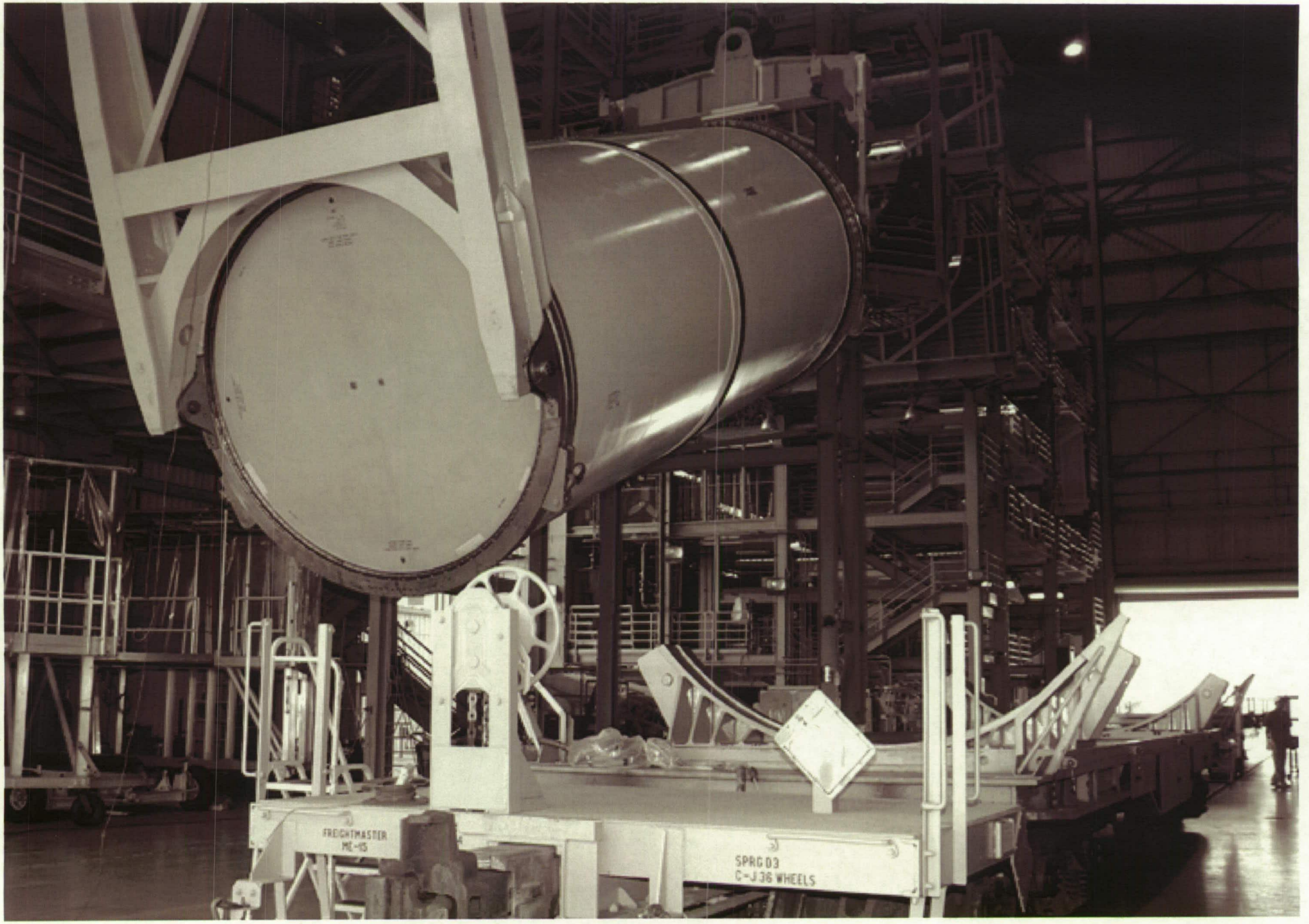


Bridge Bucket

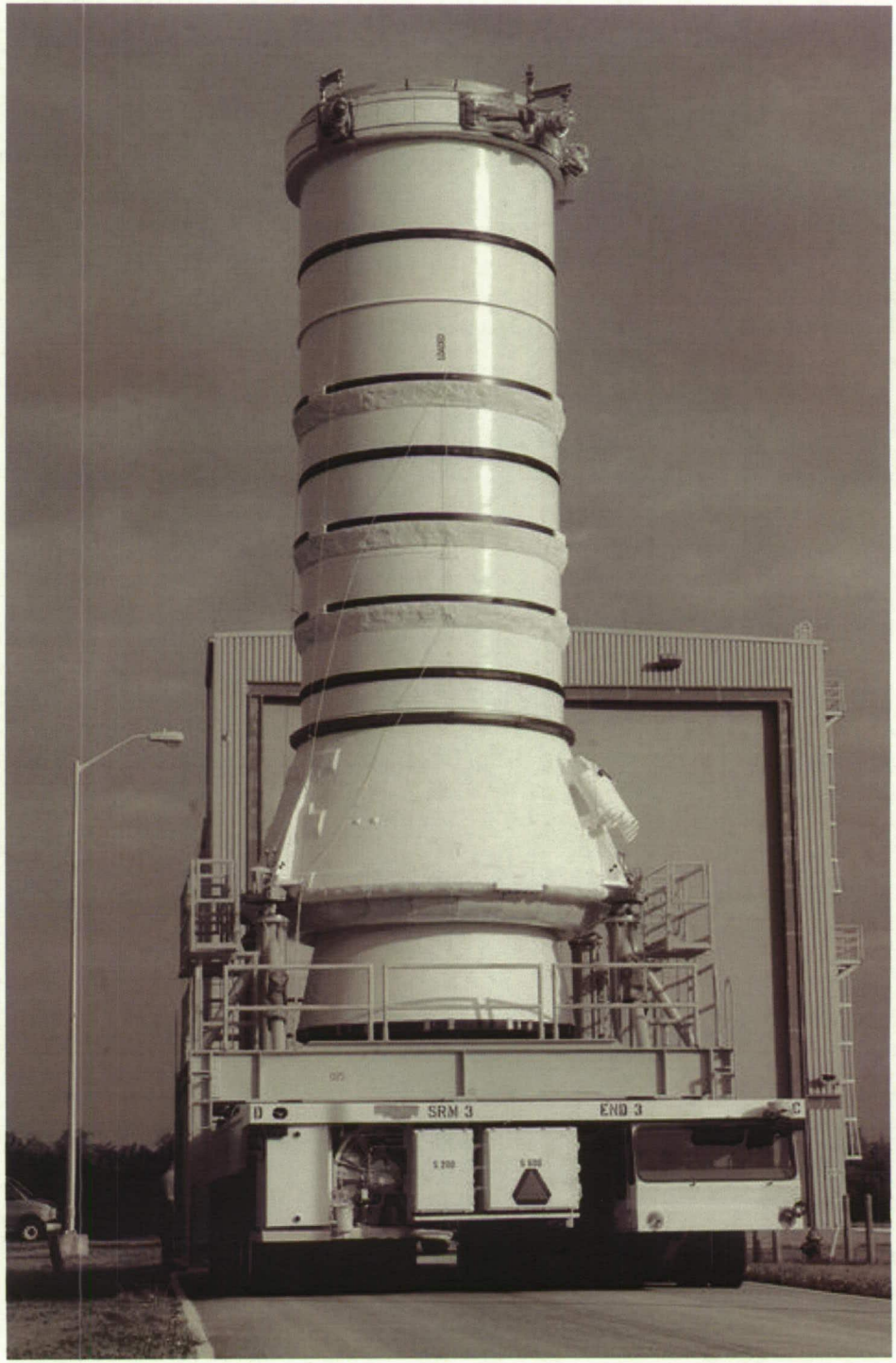


Rotation Processing and Surge Facility

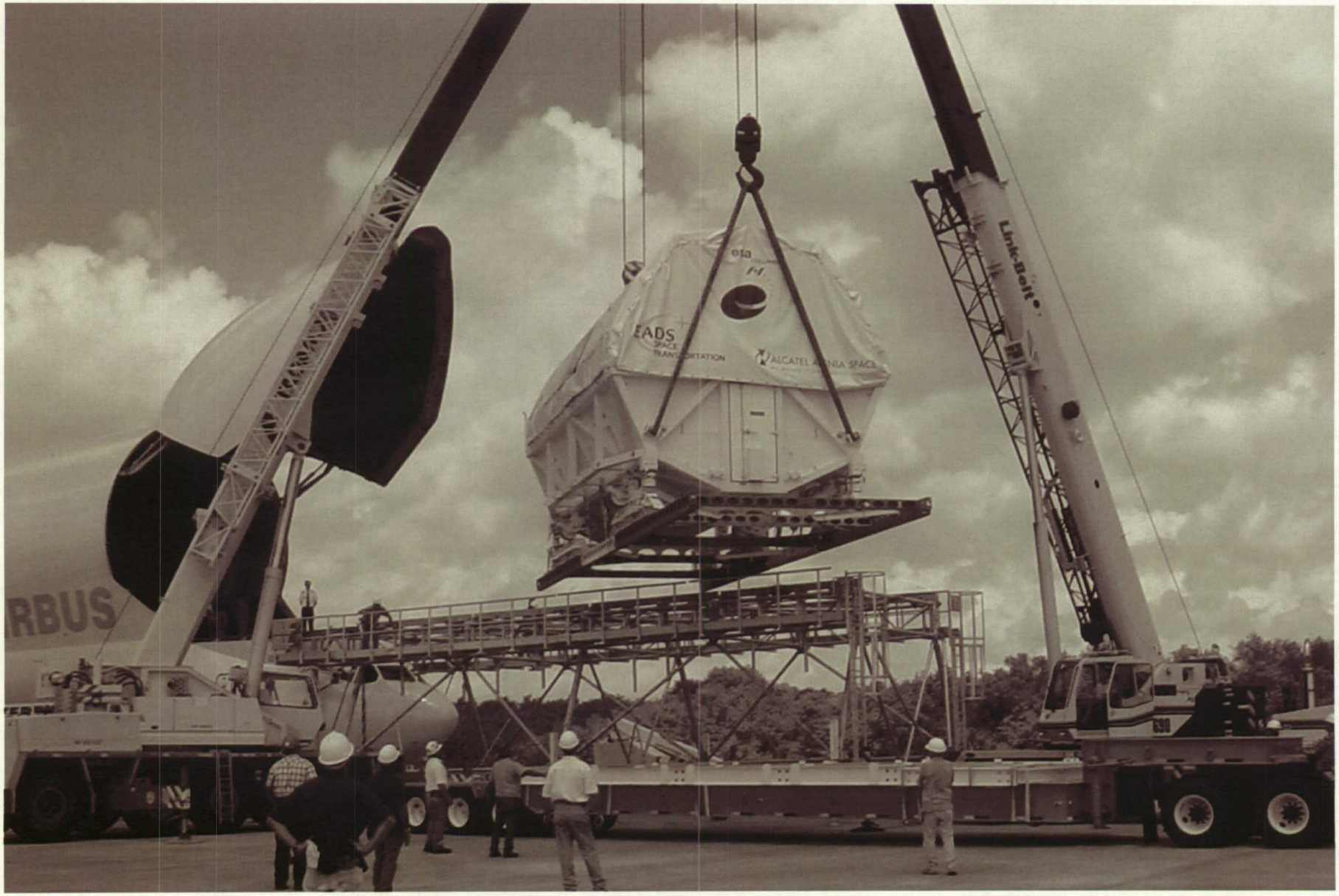



FREIGHTMASTER
ME-115
SPRG 03
C-J 36 WHEELS

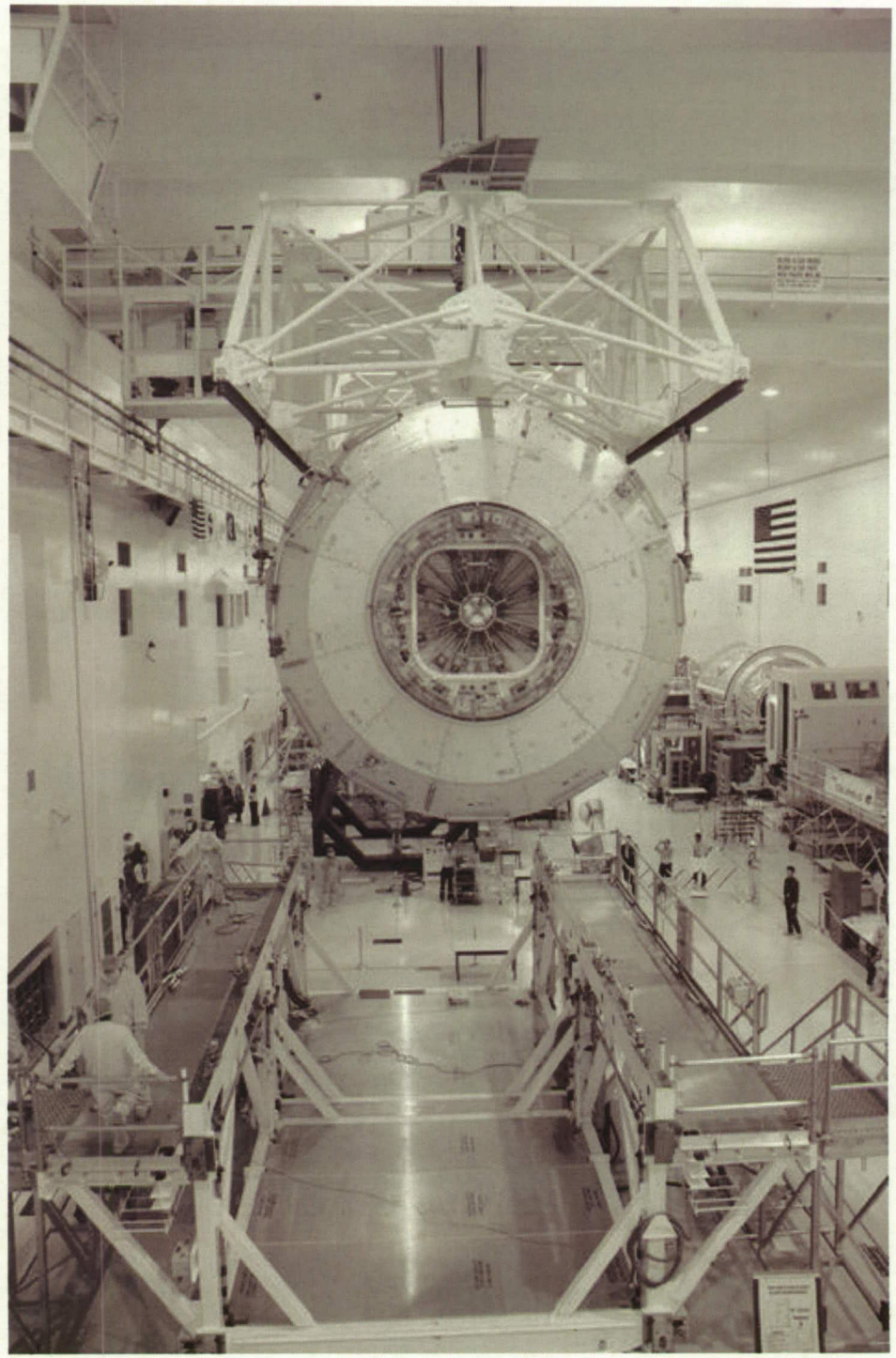
Aft Booster Segment



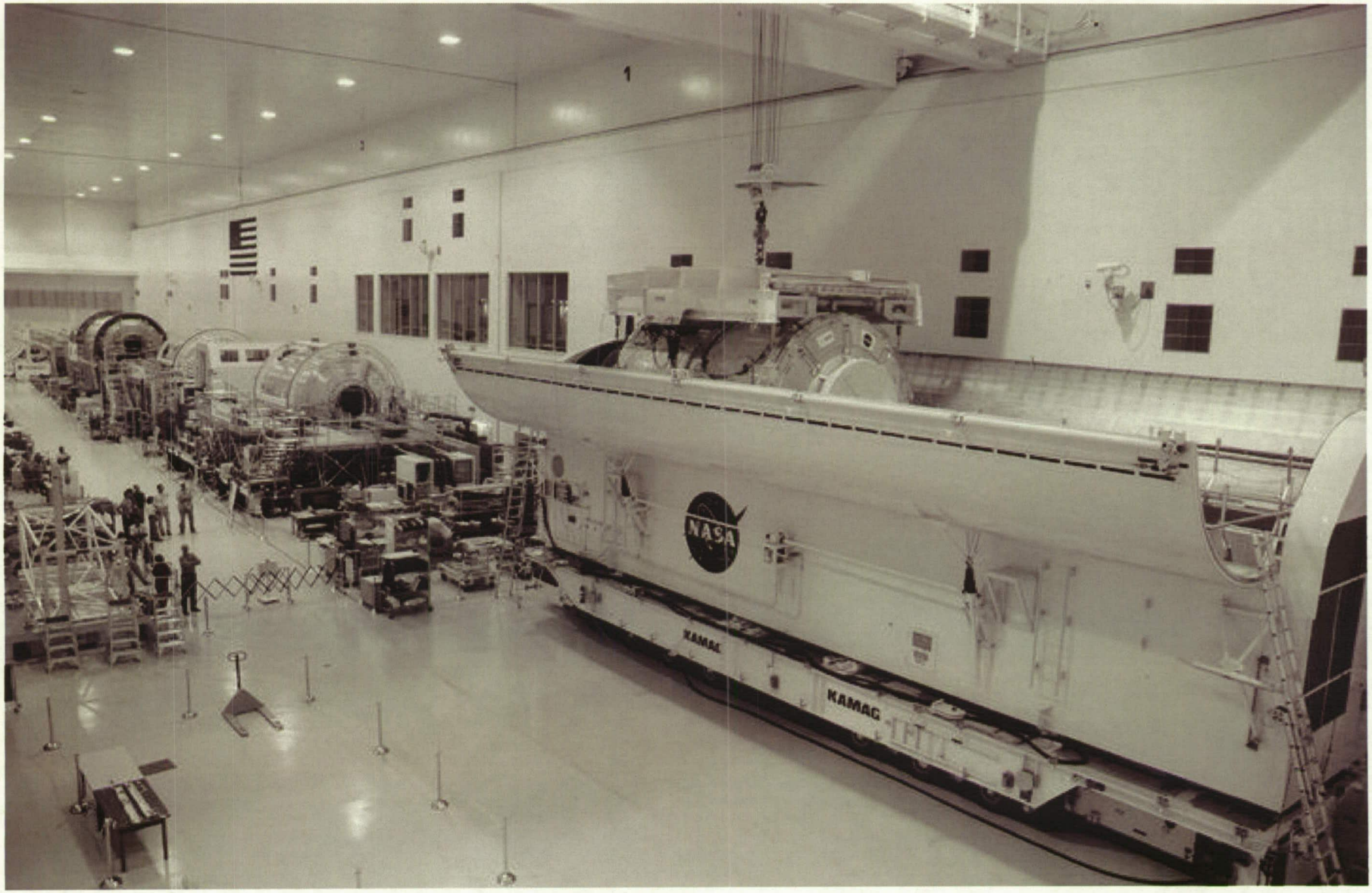
Payload



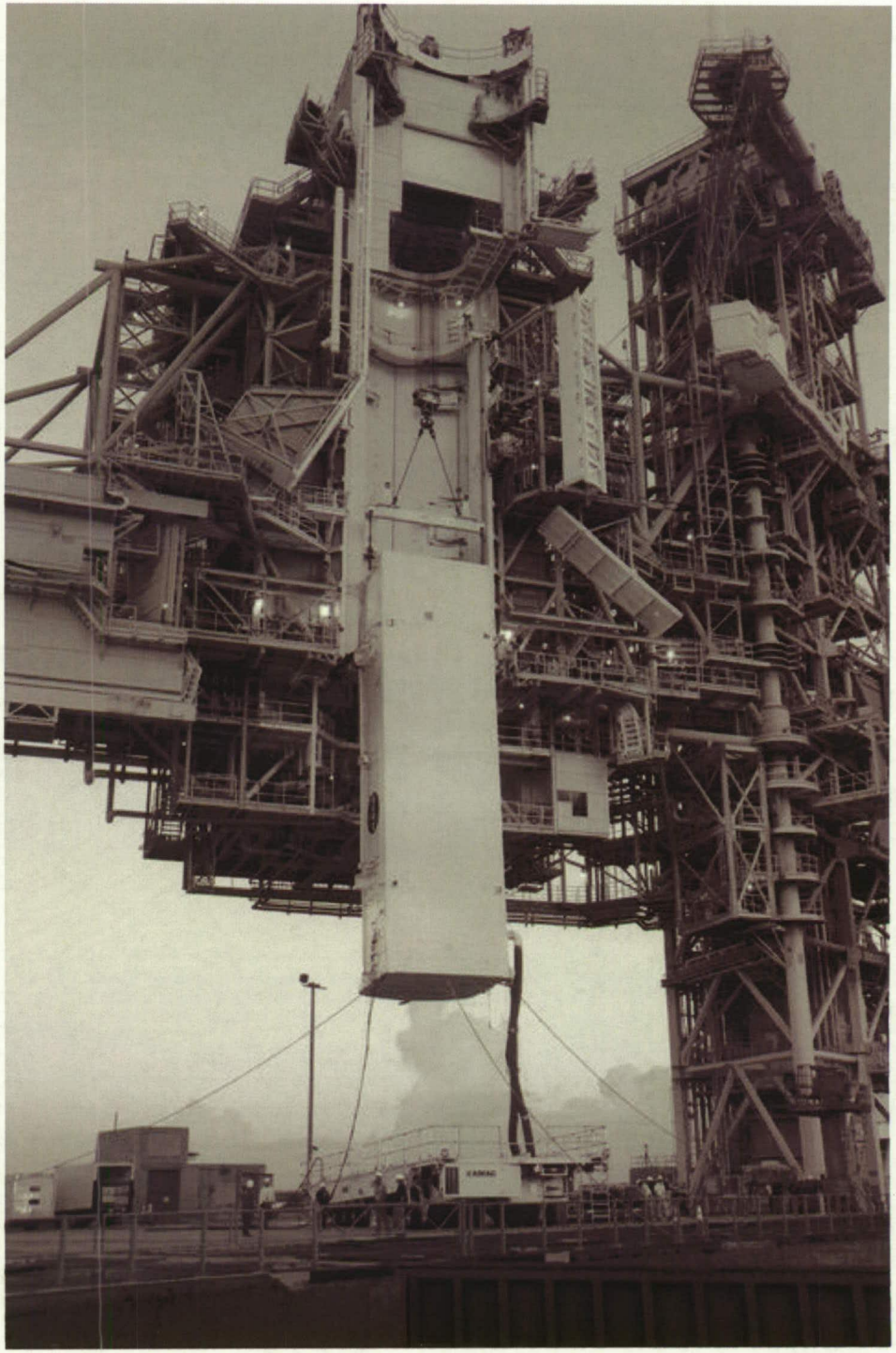
Space Station Processing Facility



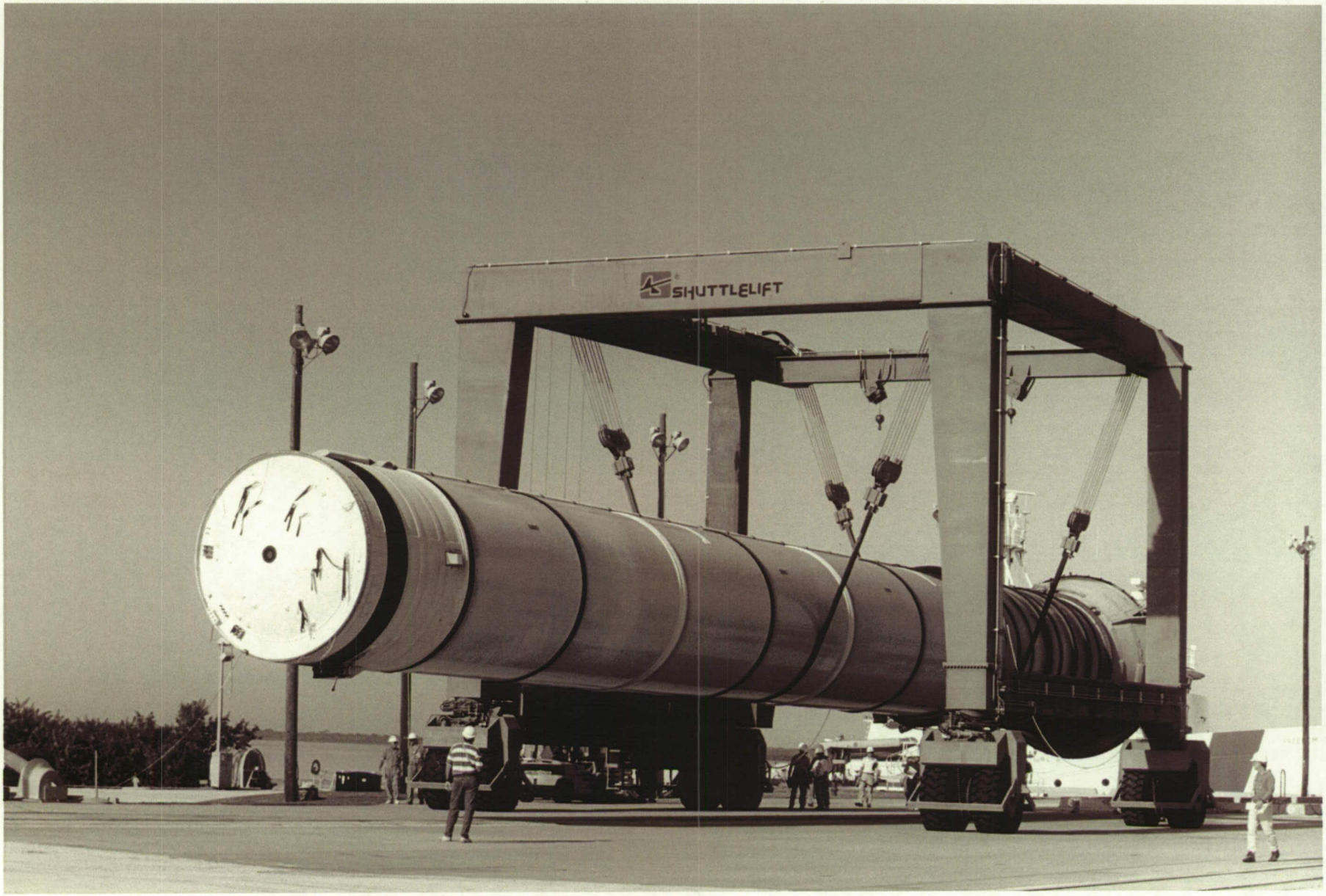
Payload Canister



Rotating Service Structure

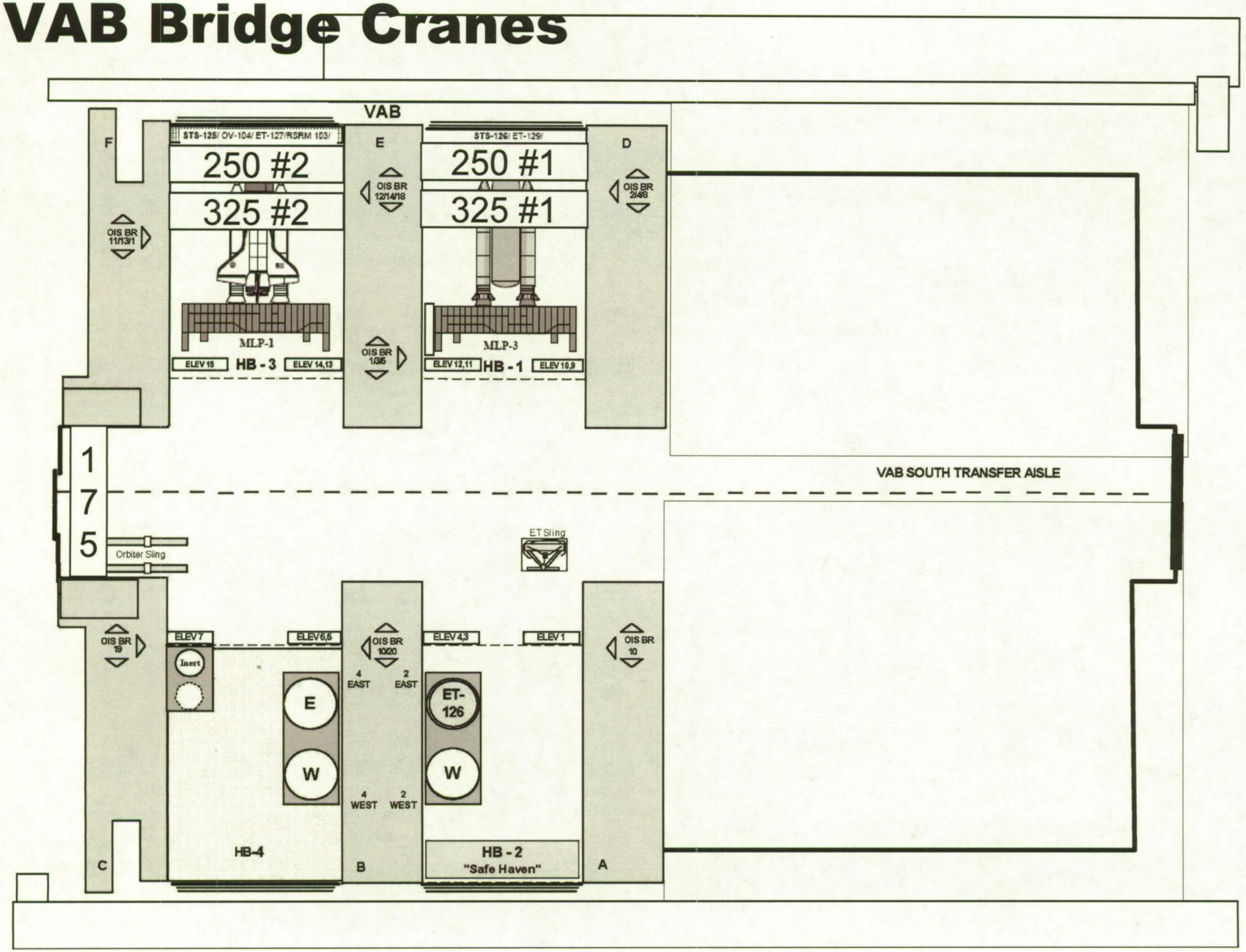


Solid Rocket Booster Recovery

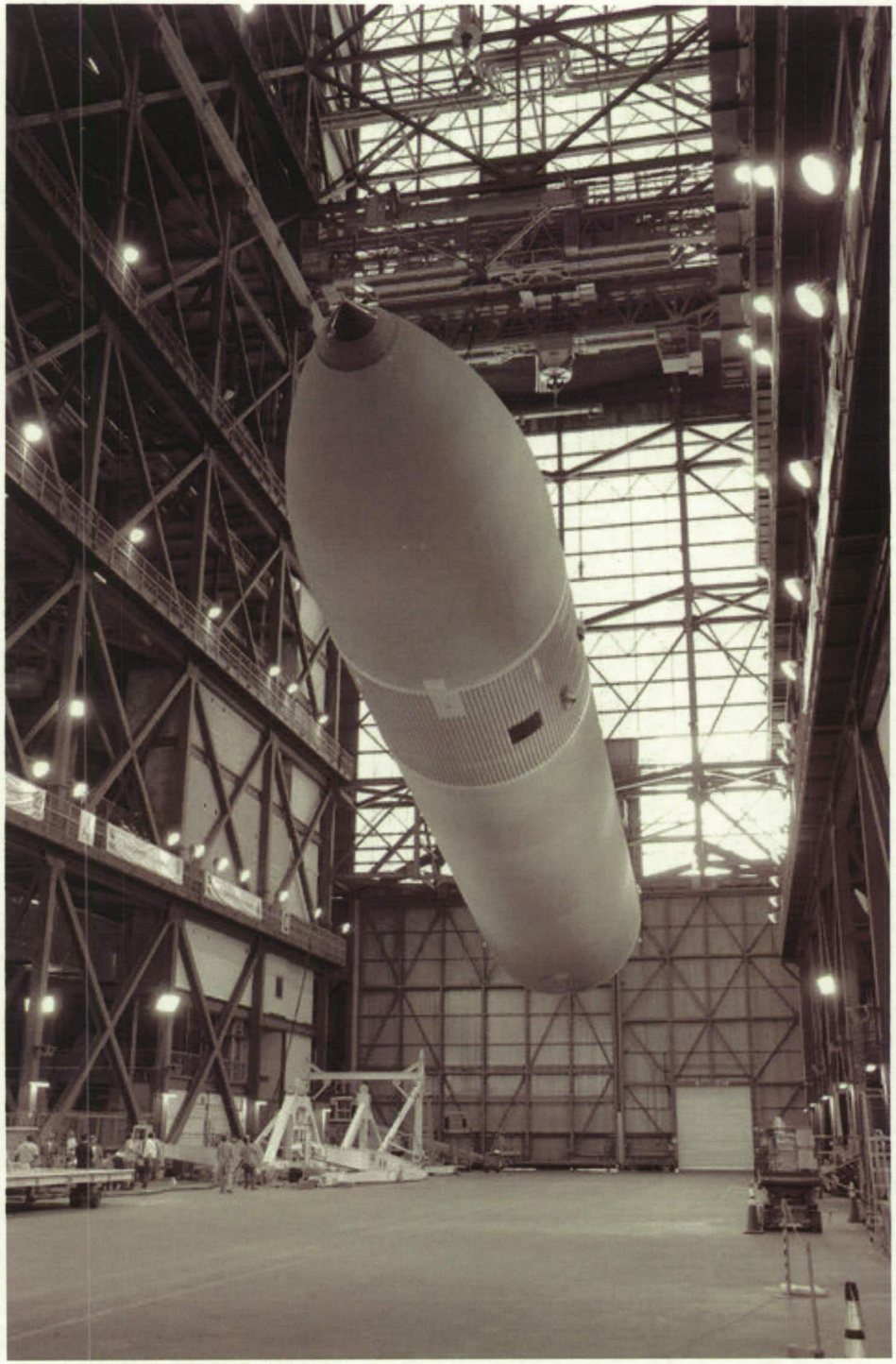


Vehicle Assembly Building (VAB)

VAB Bridge Cranes

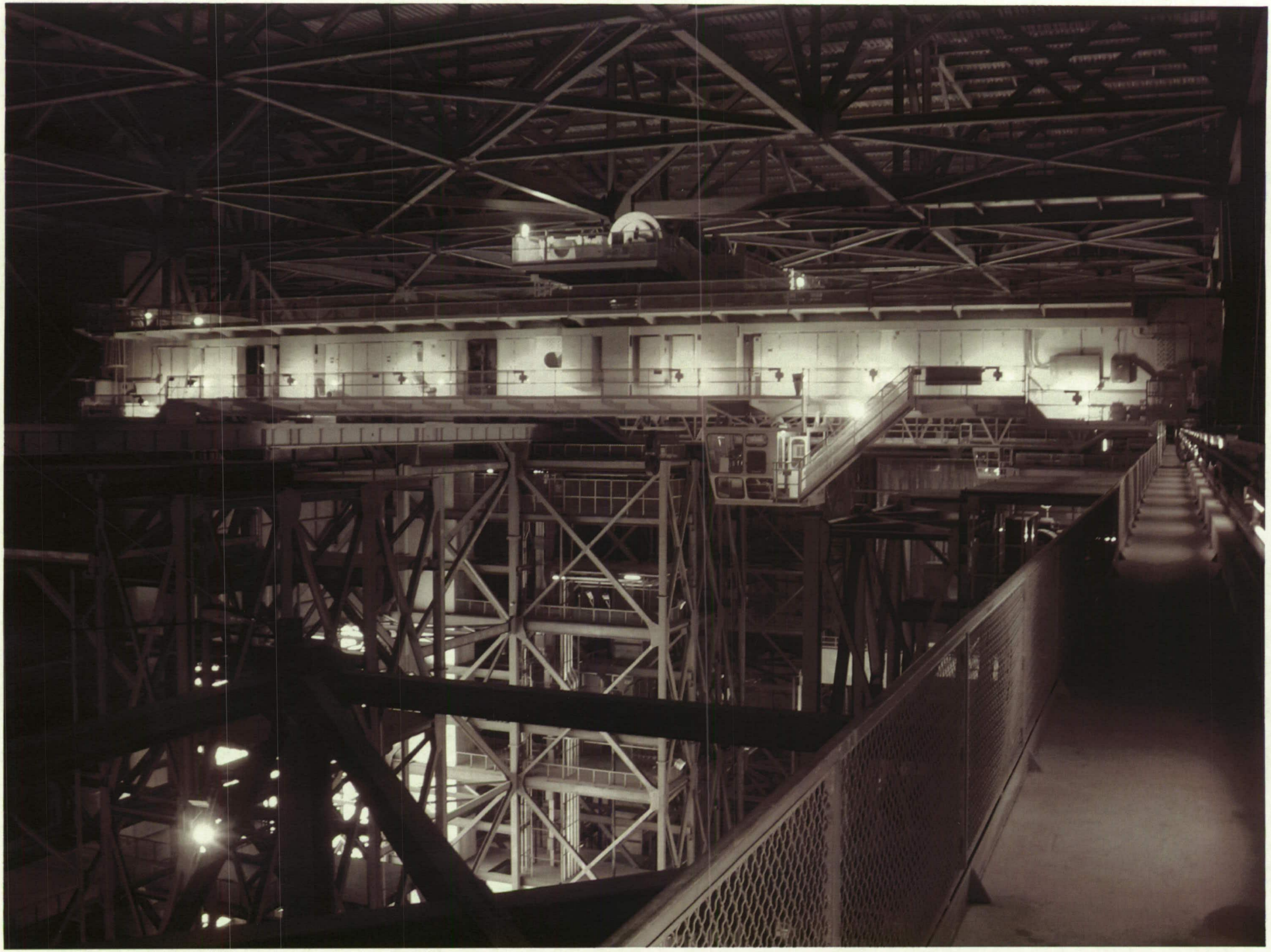


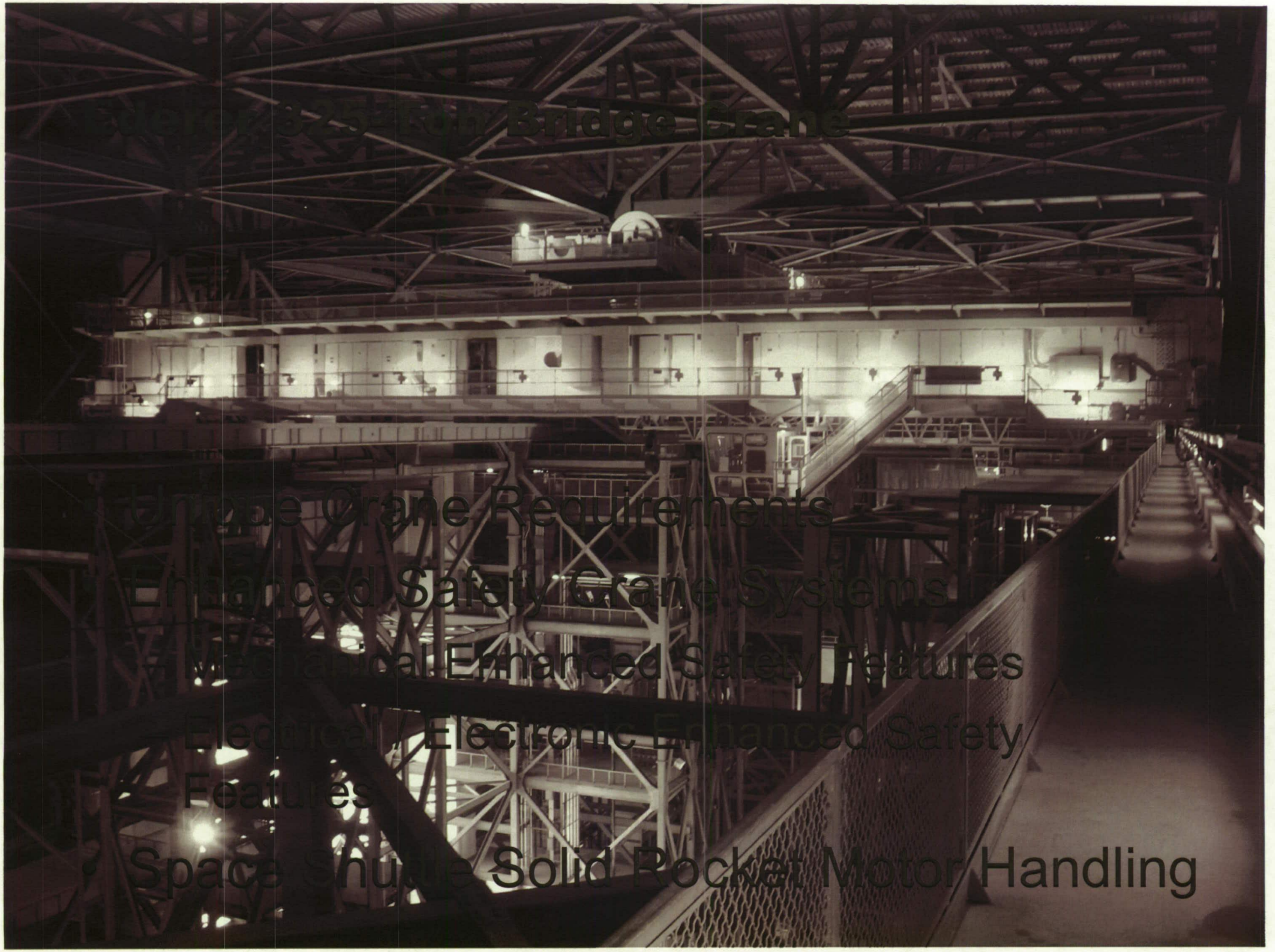
175-Ton



250-Ton

325-Ton




Bridge Crane
Bridge Crane Requirements
Enhanced Safety Crane Systems
Mechanical Enhanced Safety Features
Electrical / Electronic Enhanced Safety Features
Space Shuttle Solid Rocket Motor Handling

General Specs
– Double girder, top-running crane
– 140 feet span
– 325 ton main hoist
462 feet 6 inch lift height
– 50 ton auxiliary hoist
463 feet 6 inch lift height

Unique Crane Requirements

Handling one-of-a-kind, high-dollar equipment

- Extreme safety hazards
  - Explosive ordnance
  - Toxic propellants
  - High pressure gasses
- Precision spotting, inching and sometimes micro-inching capability
- Fragile equipment (it's like lifting an egg)
- Program risk (flight hardware represents the end product of many years of work by a large conglomerate of companies)

Enhanced Safety Crane Systems

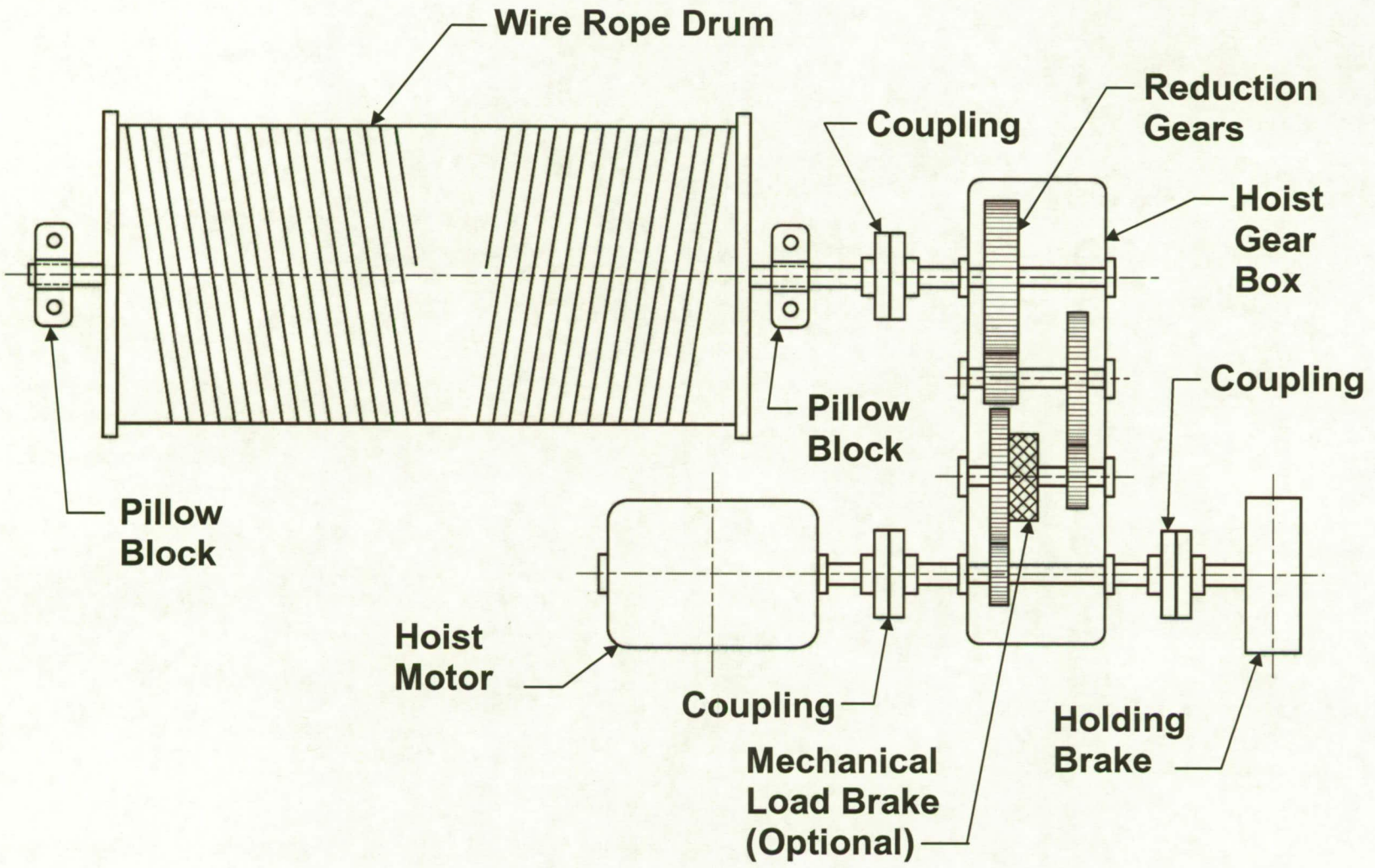
- Cranes cannot fail, this does not just mean protection from load drop. On some cranes we protect the load from uncommanded movement (i.e. the crane control system must sustain a failure of a control component and the load does not move)
  - This is easier said than done
  - Easier to achieve on Mechanical systems
  - Much harder top achieve on Electrical or Electronic /Microprocessor-based control systems
- Cranes are designed to be single-failure-proof, no single component failure can cause the crane loose control of the load
  - Cannot allow an increase in speed, or reverse direction
  - A failure that causes the crane to slow down or stop is considered acceptable

Enhanced Safety Mechanical Features

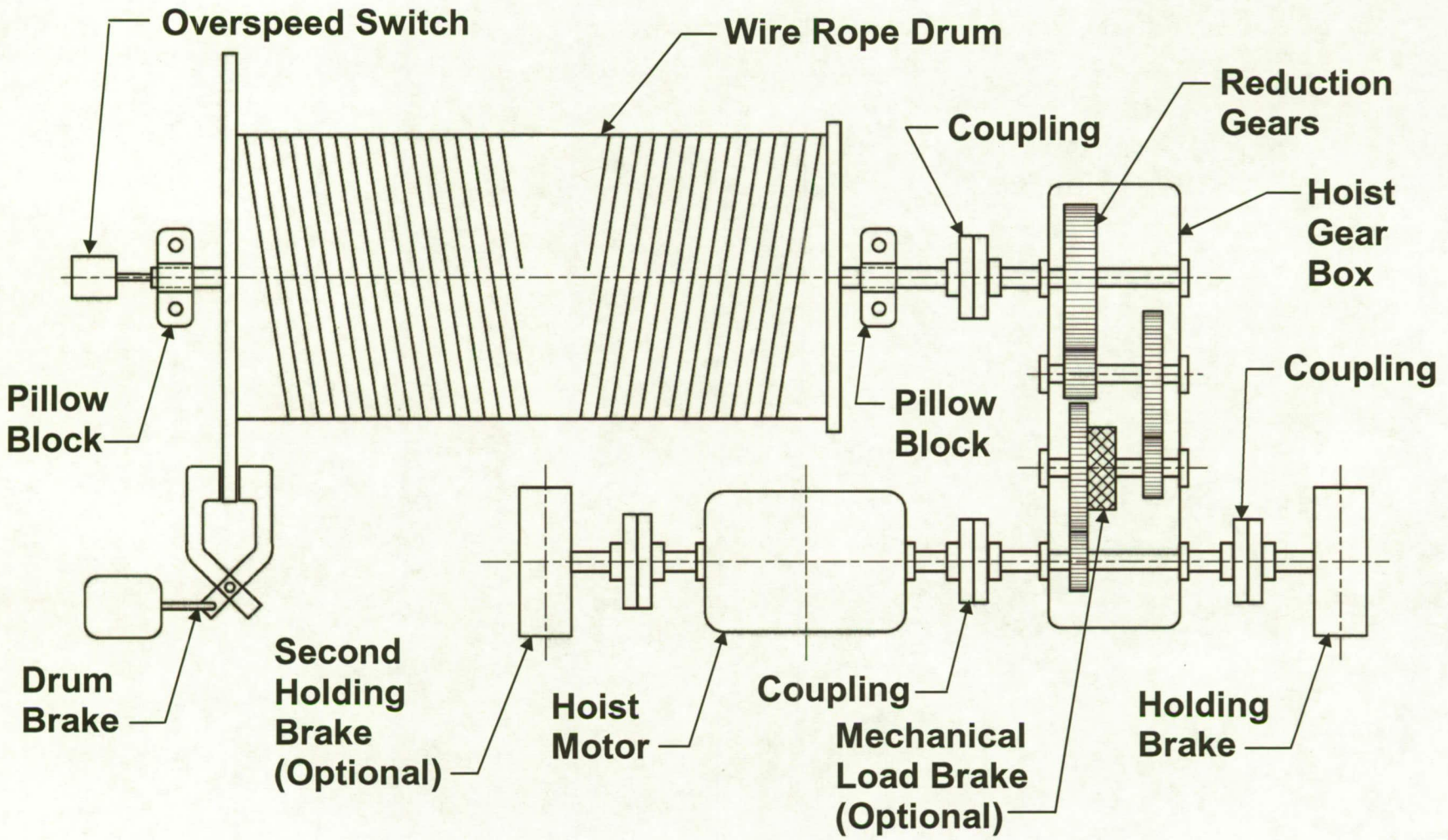
ASME NOG-1-2004, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)"

- Covers mechanical "fail-safe" requirements
- Includes items such as:
  - Emergency brake on the drum, or redundant load paths
  - Wire rope spool monitors
  - Increased design factors on components
  - Many other items too

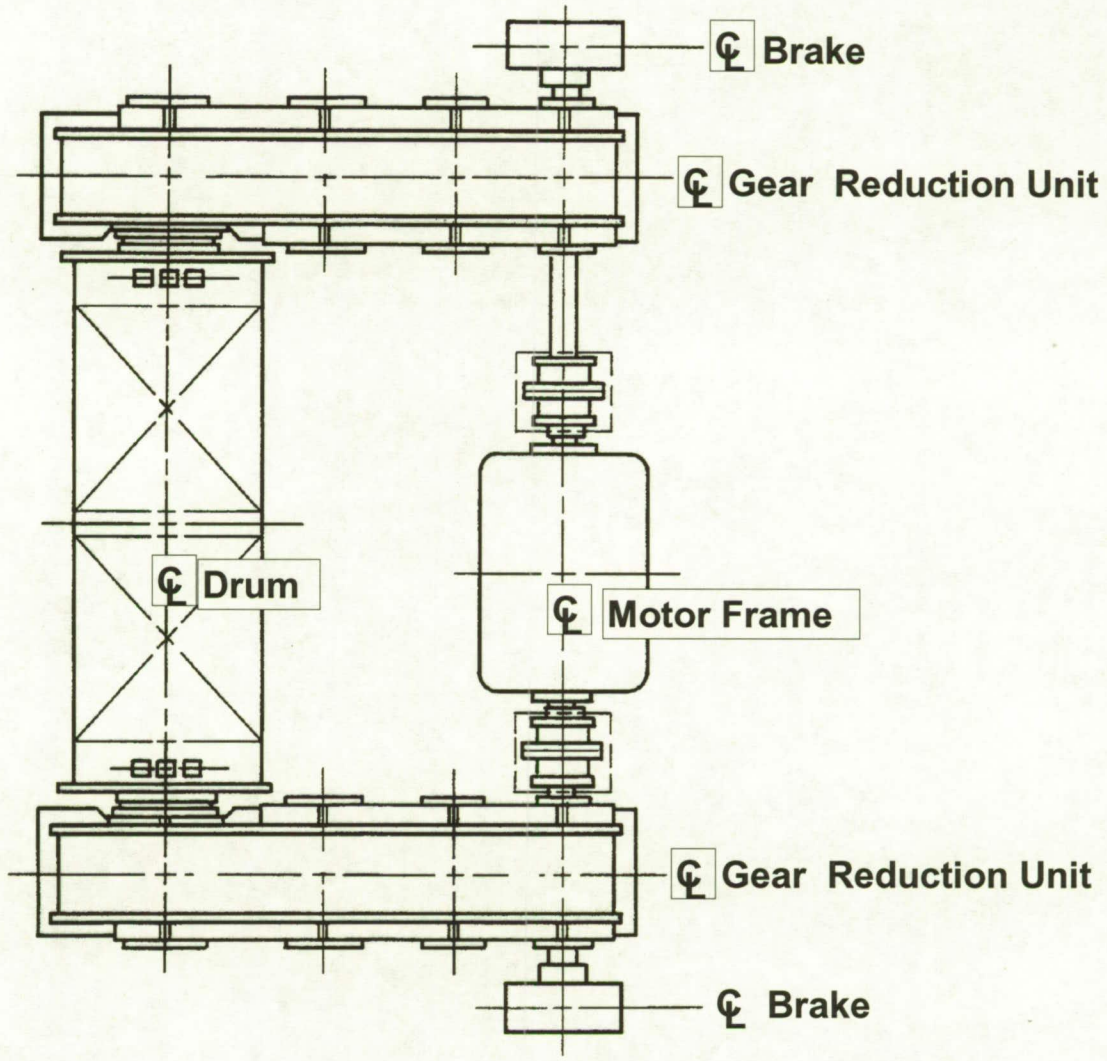
Standard Hoist Mechanical Arrangement



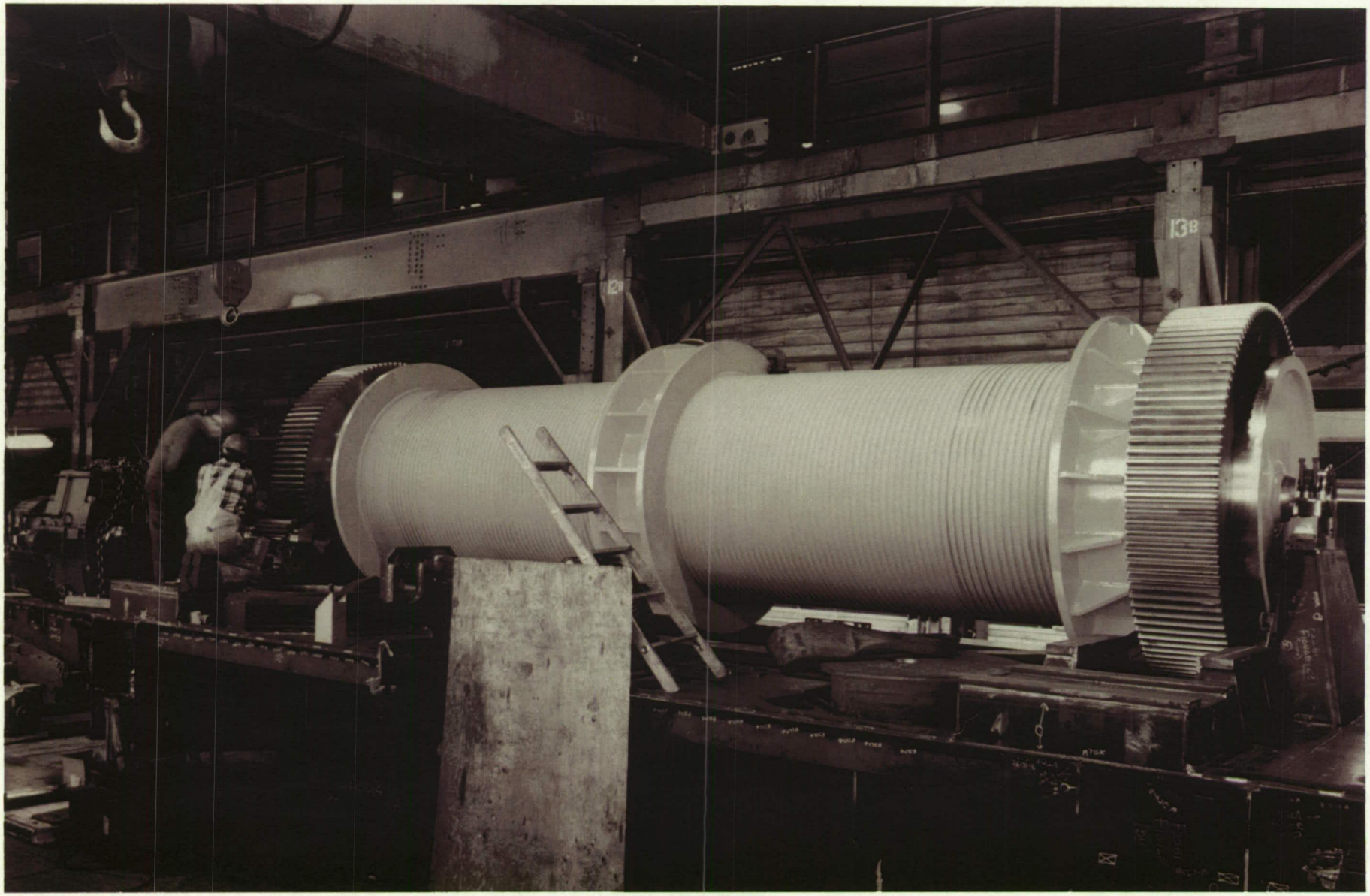
Single Failure-Proof Hoist



Typical Dual-Hoist Drive Unit



VAB 325-Ton Crane Redundant Load Paths



Enhanced Safety Electrical Features

- Electrical Fail-Safe features are covered in industry standards (applicable to all cranes)
  - Loss of power stops motors and sets brakes placing the crane and load into a safe state
- Emergency stop buttons are used at the operator's station to remove all power to the crane and set the brakes and assure the load is safe
  - At Kennedy Space Center, a second "remote" emergency stop button is located at the point where the load is handled (two crane operators have the ability to stop the crane)

Enhanced Safety Electronic Features

- Electronic controls is not adequately covered by these standards, especially when microprocessor based systems are used
- Today users are requiring more from the crane controls (and more electronic controls are used)
  - Precise control of load is required
  - Critical loads are handled in close proximity to other items
  - The time it takes an operator to react to incorrect load motion (push an emergency stop button) is too slow to prevent an accident
    - Also, can the operator see the load?
    - Is the operator able to perceive an incorrect load movement?

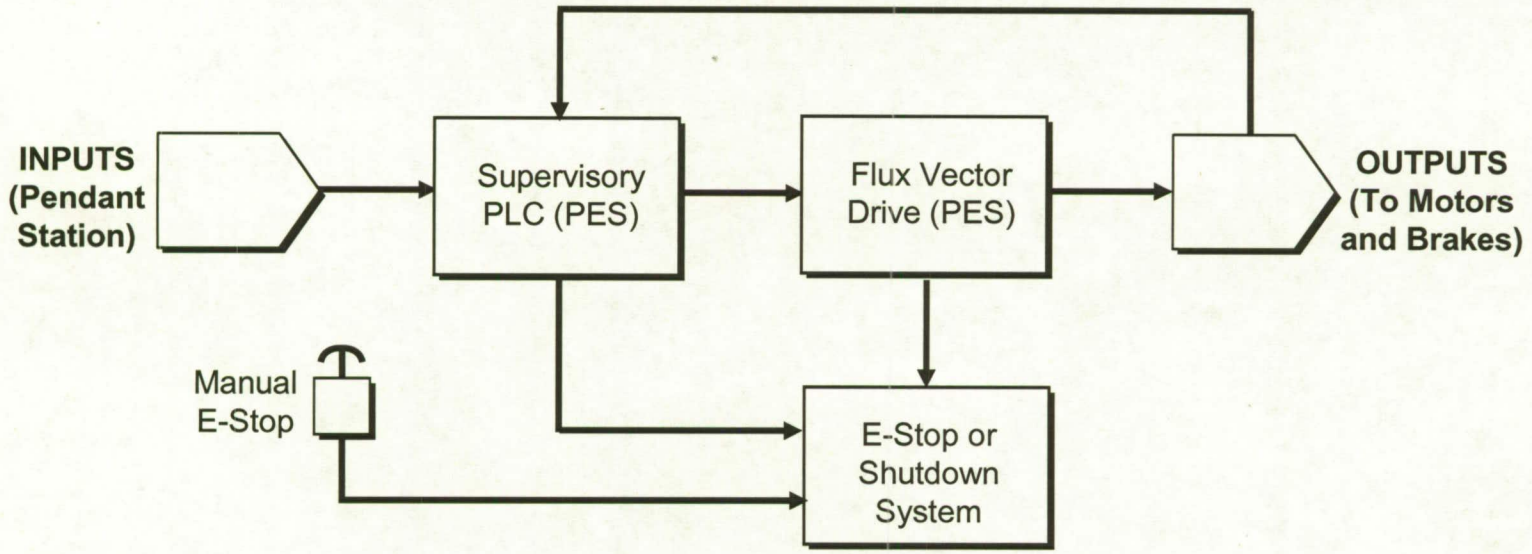
Enhanced Safety Electronic Features

- Electronic controls can add supervisory control systems that provides emergency shutdown features
  - Feedback circuitry, error checking, diagnostics
  - Automatic safety shutdown to keep the load safe is possible
    - Remove power from the crane—everything is safe

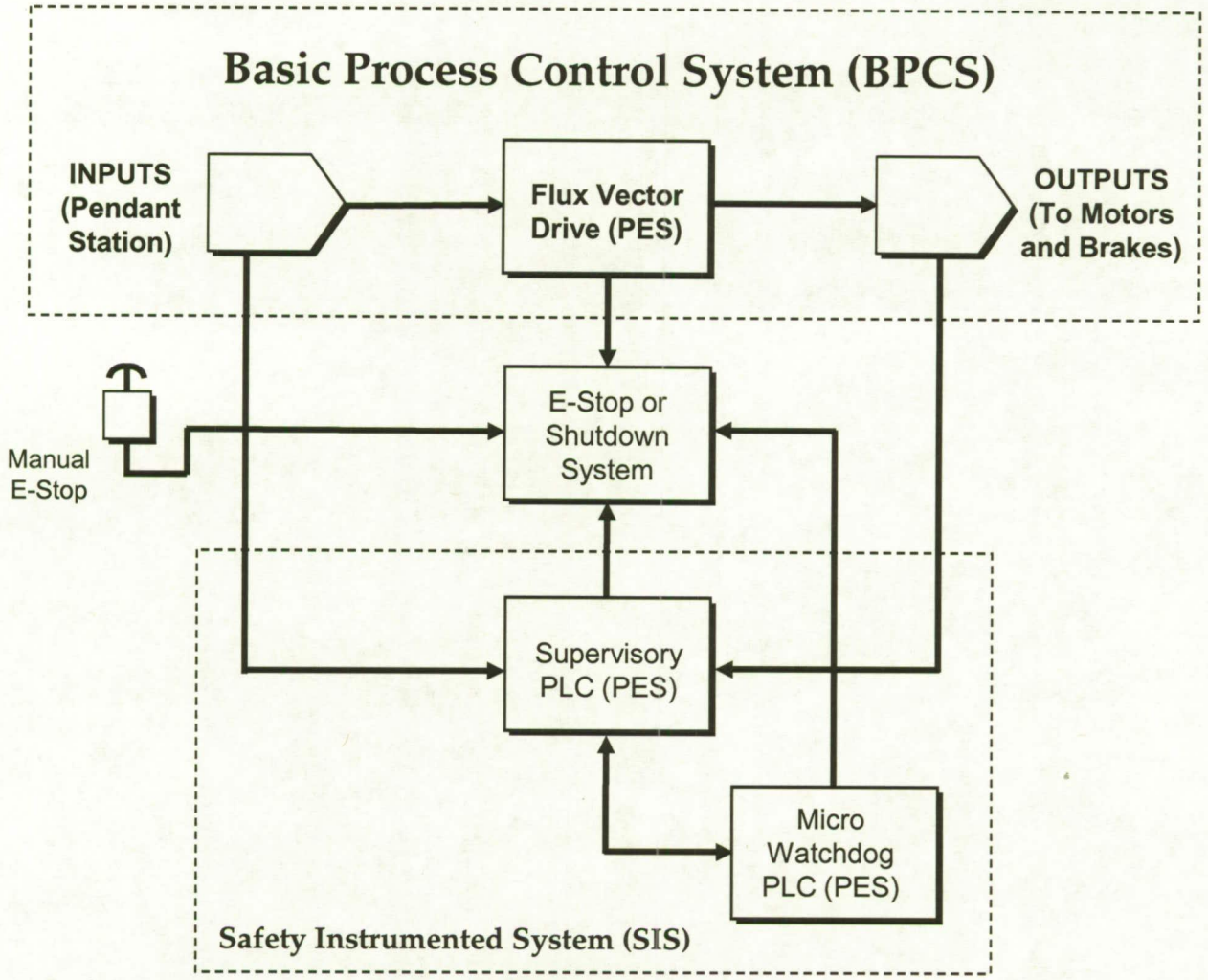
Enhanced Safety Electronic Features

- Reliability analysis should be completed to assure all parts can fail safely—including the supervisory controls
  - All parts will eventually fail—it's just a matter of when
  - Control system design must accommodate these failures and keep the load safe
  - If not designed correctly, the failure of the supervisory controls can directly lead system failure

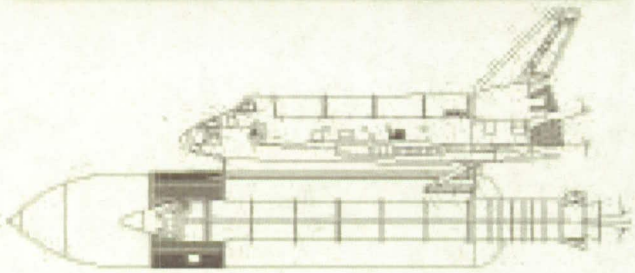
Enhanced Safety System Architecture
Incorrect (Serial) Configuration



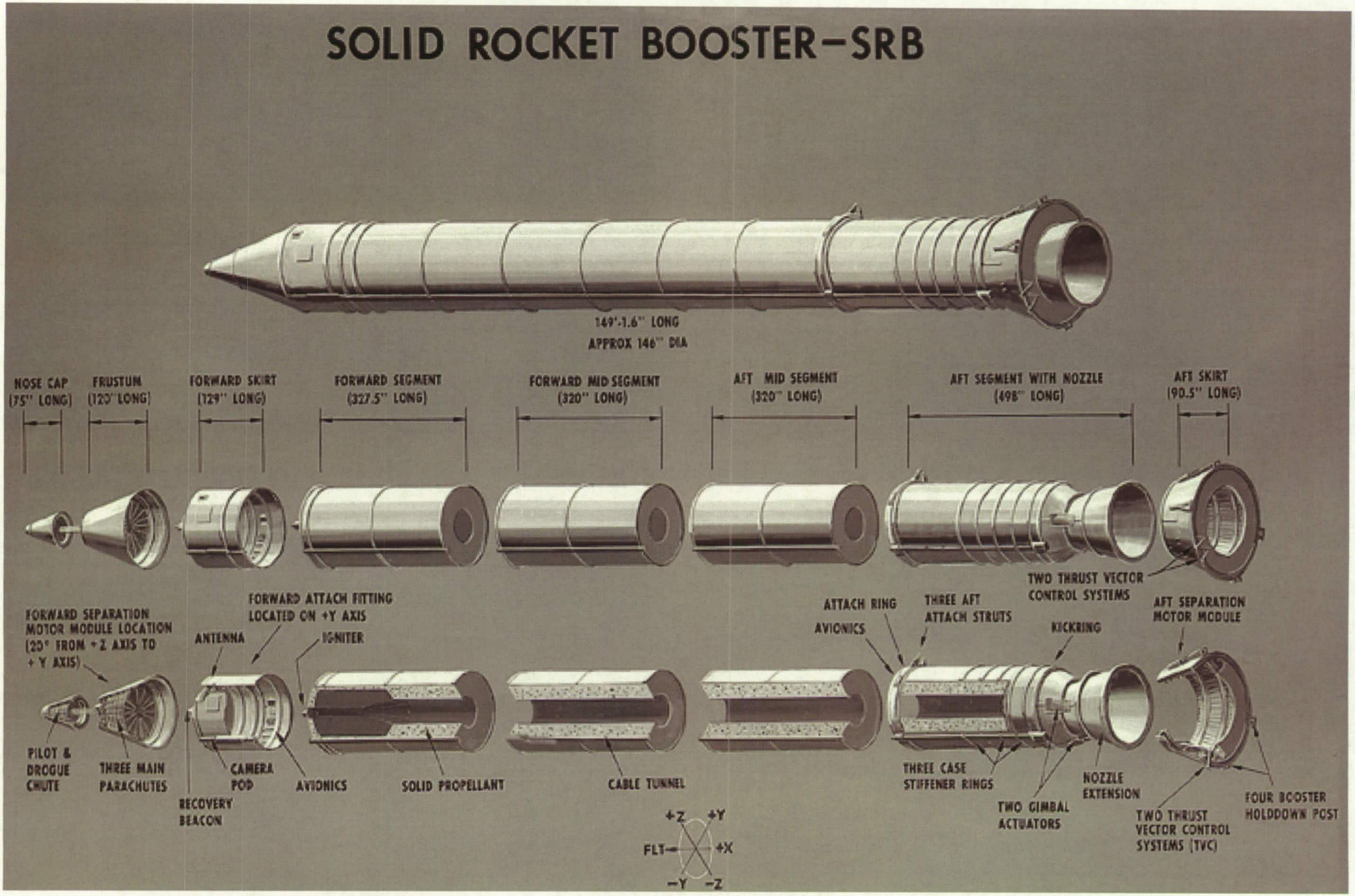
Enhanced Safety System Architecture
Correct Configuration



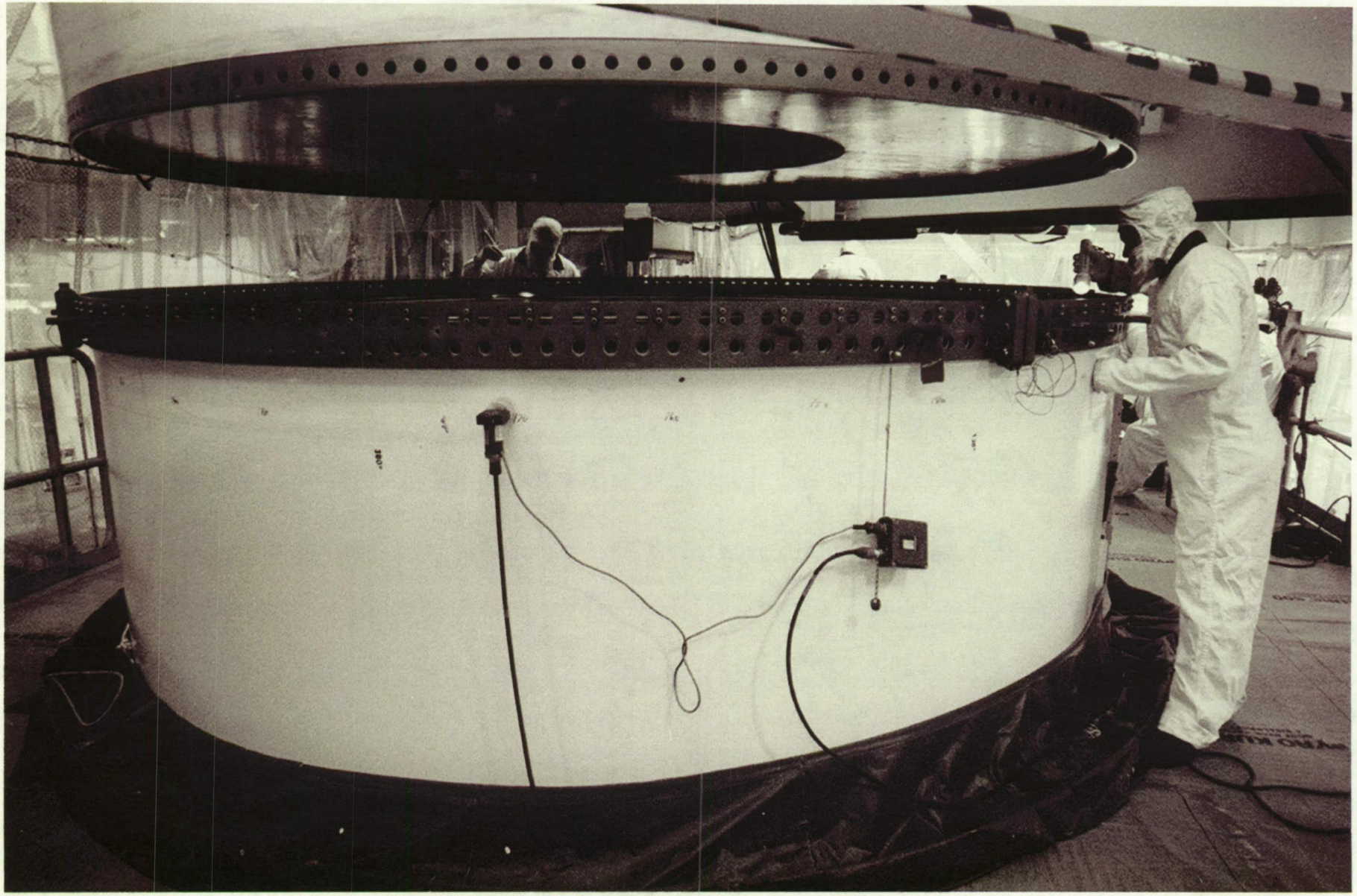
Space Shuttle Solid Rocket Motor Handling

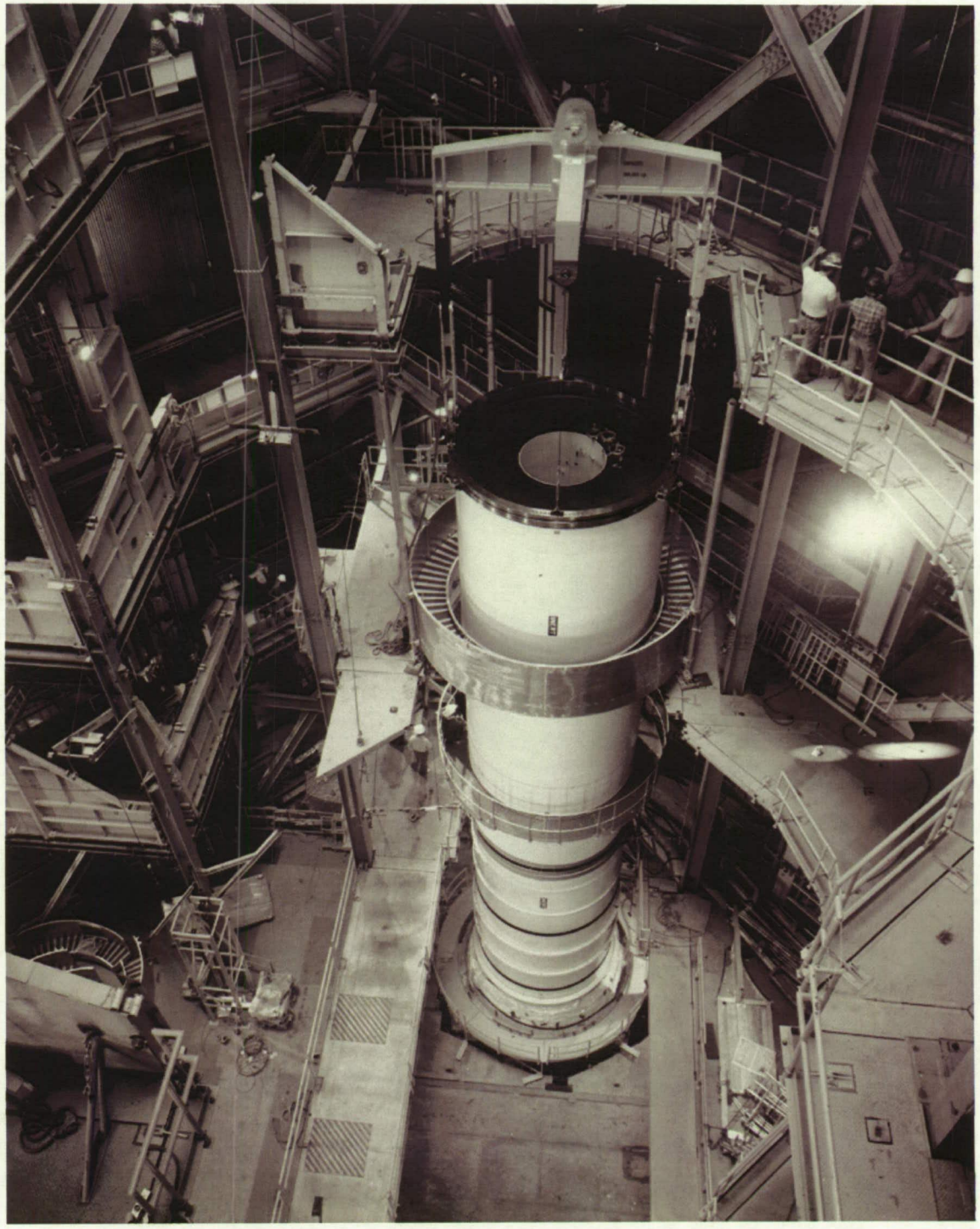


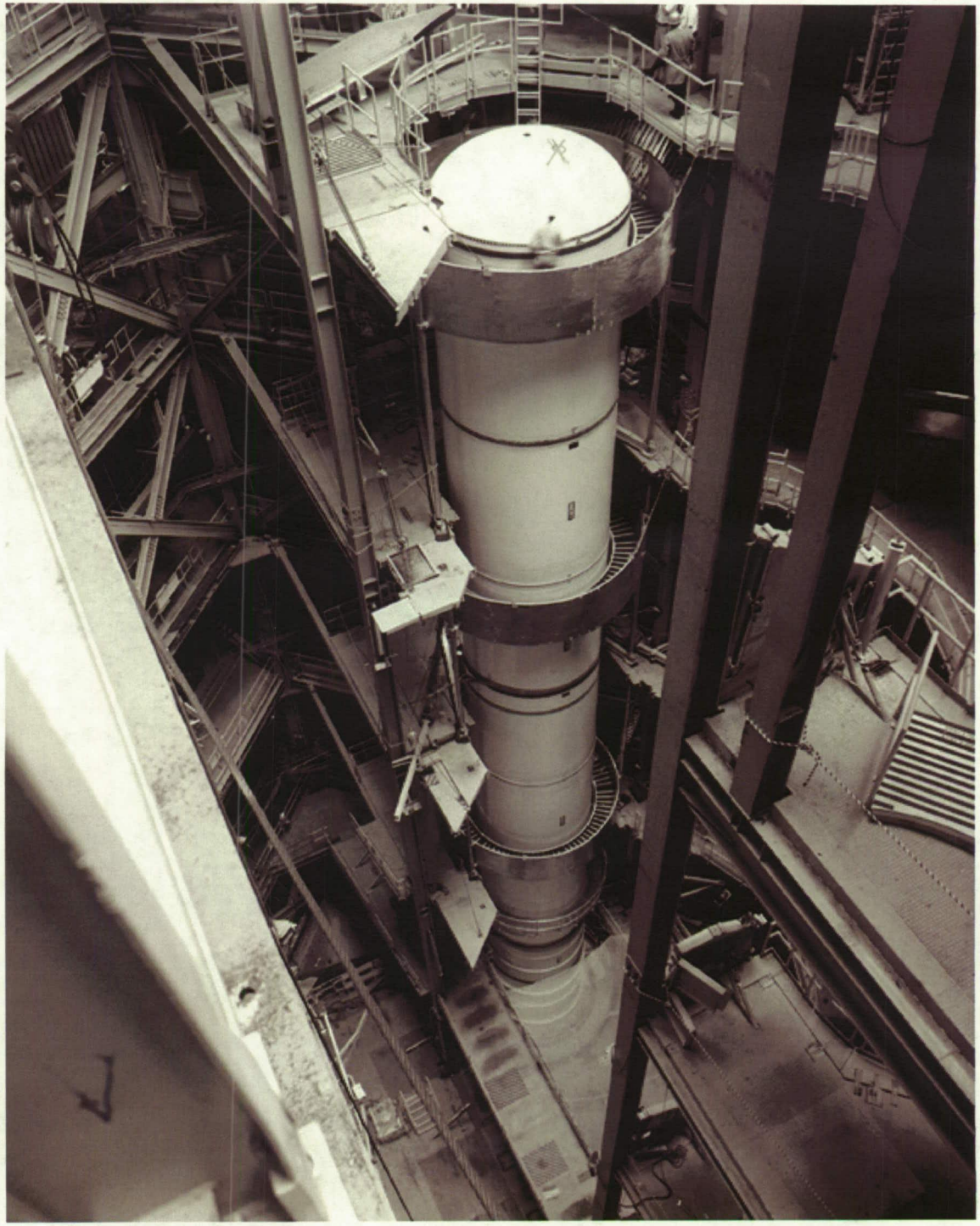
Space Shuttle Solid Rocket Booster

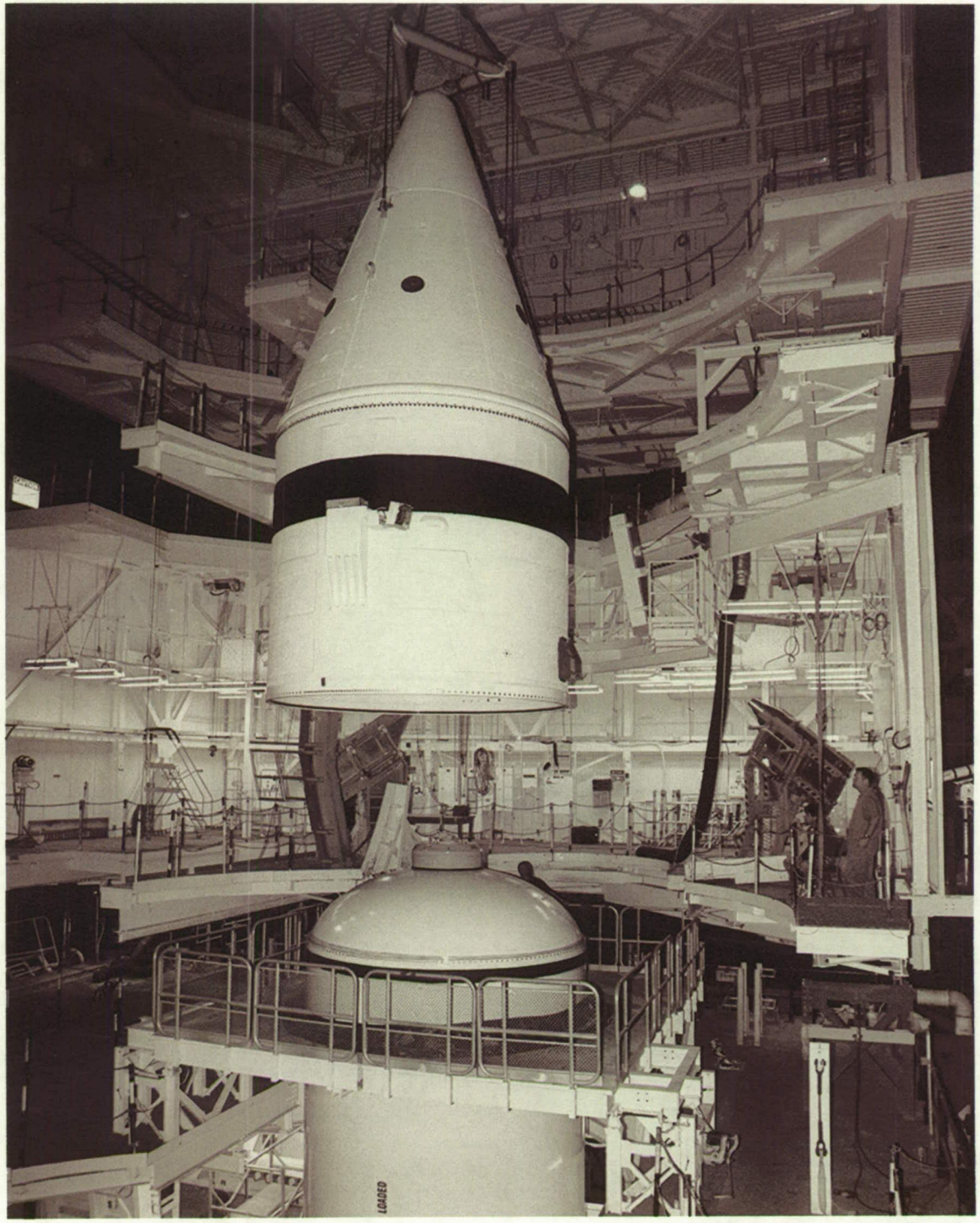


Solid Rocket Motor Segment Mating





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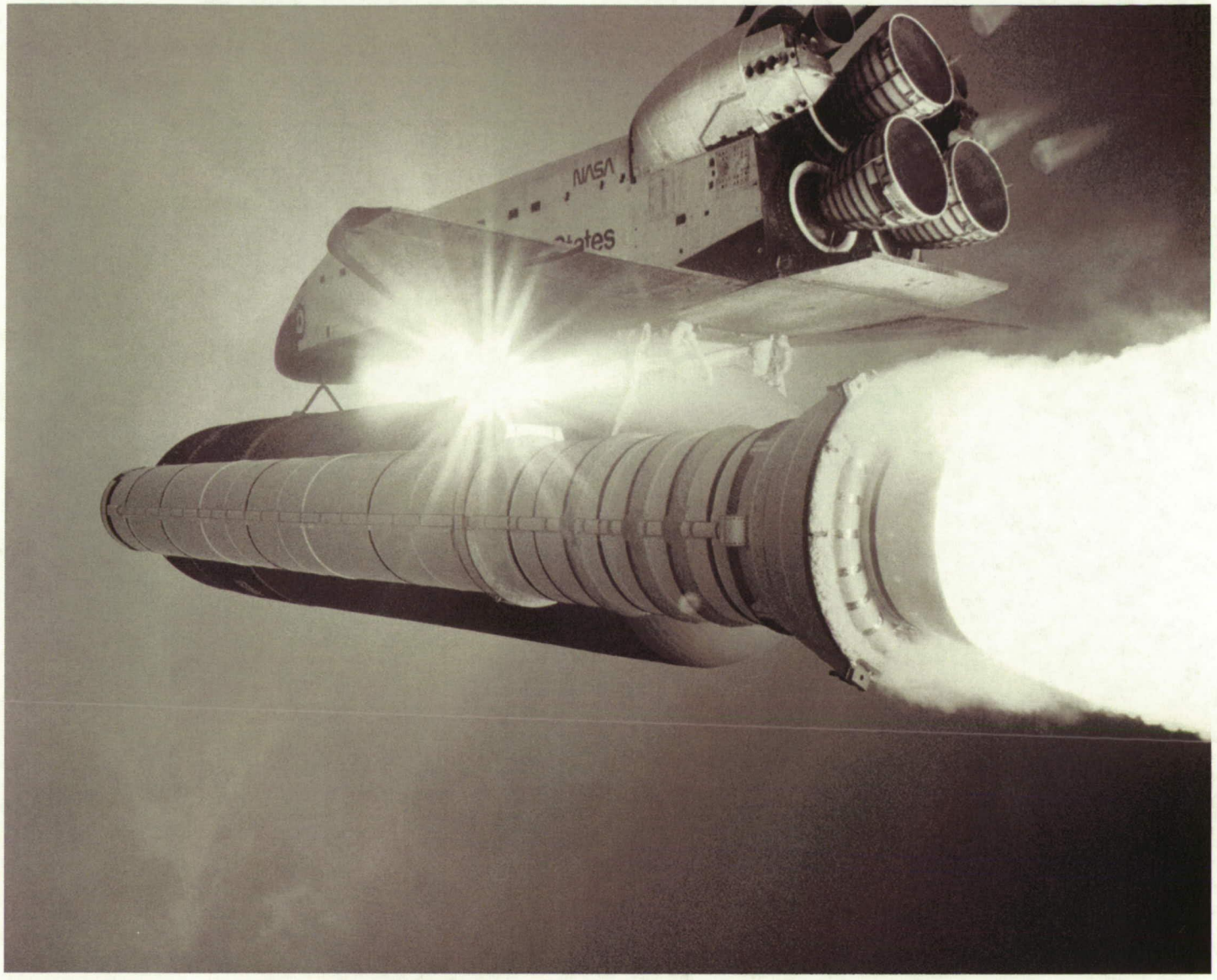
NASA

Crane Design Features

- Enhanced Safety Design
- Redundant mechanical load paths on the hoist
- Supervisory controls independently monitor basic crane operation control system providing automatic safety shutdown

Final Note

- We have to do a lot to meet NASA enhanced safety requirements.
- These requirements are there for many good reasons. They are valid and they have been embraced by the Kennedy Space Center team.
- It is up to us to implement these requirements so that true "enhanced safety" design is achieved.
- What has been presented here covers one of the most hazardous material handling applications. The custom supervisory control system is not for every critical application. If you are interested in "ultra safe" control systems, I would be glad to talk to you.

QUESTIONS ?

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NASA Homepage

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